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ABSTRACT

Activities which study how water is used, contaminated, and treated or purified are presented in this curriculum guide, culminating in the investigation of a local water quality problem. Designed as a 12 week mini-course for students in grades eight and nine, the guide first presents a review of the content, objectives, major concepts, and sources for student reference materials. Major topics or units of study are titled: Water, a Renewable Resource (Hydrologic Cycle); Is Water a Renewable Resource?; Scientific Analysis of Local Water Quality; and A Local Study of Water Quality. Each unit is composed of a series of pre-, major, and post-activities beginning with a general overview indicating title of the unit, purpose or objective, abstract of content, and unit schedule of activities, including time allotments. Individual activities enumerate, where appropriate, background information, major points to emphasize, questions or quizzes, teaching procedures, materials required, and supplemental activities or information. A variety of media and processes is suggested to allow for flexibility. This work was prepared under a contract for an ESEA Title III project, "Environmental Science Study Curriculum." (BL)

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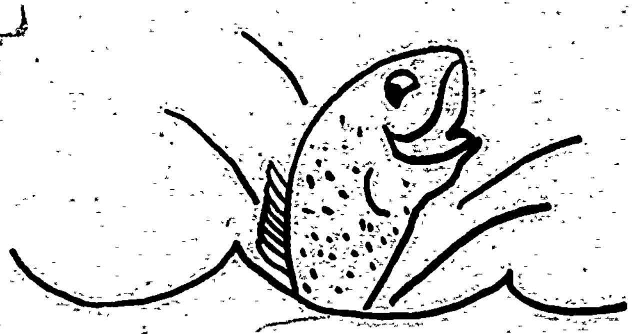
WATER



QUALITY CONTROL

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PUBLISHER'S NOTE

Environmental Science Study Curriculum, (ESSC) is an ESEA Title III project funded through the State of North Carolina. One purpose of project ESSC is to develop a curriculum in environmental education at the eighth and ninth grade levels. The structure of the curriculum is based on the mini-course design. Currently, there are six twelve-week mini-courses, "Water Quality Control" being one such course. Although the materials contained herein are designed for the specified grade levels, they could be utilized over a wider span of grades with relatively little revision.

Another purpose of the project is to review as much of the available and existing materials as possible and to utilize them wherever possible. Therefore, not all of the materials and ideas contained herein are the original work of Project ESSC, rather some of this material is the result of using, evaluating, reworking, combining, synthesizing, and re-evaluating existing materials from many varied sources. It is for this reason, however, that we are unable to credit all the original sources on those materials that are not original ideas of Project ESSC.

It is the hope of Project ESSC that this material and these unit plans are presented in such a manner that they will be readily usable. This entire course or any part thereof may be reproduced without any further permission from Project ESSC. However, we do ask that credit be given if the total course is reproduced.

WATER QUALITY CONTROL

A Curriculum Guide

Prepared By

Environmental Science Study Curriculum

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CONTENTS

ENVIRONMENTAL QUALITY CONTROL - WATER

There are many ways this course can be taught. Consequently several different methods are given for many of the activities, as well as alternative activities. It is suggested that you read through the course in its entirety so that you will become familiar with the general idea of the course content. Once involved in the course your direction will become evident (based on your students' abilities, comprehension, and receptiveness to the activities). Realizing that some individuals will have different time allotments a great wealth of possible (and "workable") materials is given. It cannot all be done in twelve weeks; it doesn't have to be. You must decide what to include in your course, and what must be eliminated. To assist you in mapping out your schedule, approximate time periods for many of the activities are given. Naturally these can be adjusted depending on your students' response to the materials.

ABSTRACT

Students learn how water is used and contaminated; the effects of many pollutants on natural ecosystems; how to detect the presence of several common pollutants; and how some pollutants may be removed or eliminated by both natural and artificial processes. Students then select and investigate a local water quality problem. This problem is identified and defined as completely as possible, and a plan for solving it is formulated and implemented, recognizing and accomodating the economic, political, sociological, scientific, and natural factors.

OBJECTIVES

For students to gain the skills necessary to recognize water pollution.

For students to be cognizant of the various channels open for bringing about environmental change and the constraints produced by the interaction of social, political, and economic factors.

For students to be cognizant of the interrelationships of the causes and effects of water pollution.

CONCEPTS

a. defining environmental pollution

b. identifying a water pollution problem with emphasis on; where to look; what to look for; how to test for

c. the causes and effects of water pollution

d. achieving environmental change (channels)

e. the interaction of social, political, and economic factors and the constraints they may produce

MATERIALS

Because there is a wealth of reference material available, the bibliographies are very long. We have found, however, that we can effectively teach the course without the reference material. These references can be considered supplemental (i.e., for the academically advanced student) and not essential. If you write the following agencies you will receive gratis all the student reference materials you will need:

Charles Pou
Environmental Protection Agency
Public Affairs Office
Region 4 Office
1421 Peachtree Street, N.E.
Atlanta, Georgia 30309
Phone 404-526-3004

State Department of Public Health
P. O. Box 2091
Raleigh, North Carolina 27602 (address to your state capital)

State Environmental Protection Agencies

Department of Natural and Economic Resources
P O Box 27687
Raleigh, North Carolina 27611
Phone 919-829-4984

North Carolina Water Pollution Control Association
P O Box 1126
Chapel Hill. North Carolina ~~27514~~

Citizens Advisory Committee on Environmental Quality
1700 Pennsylvania Avenue, N.W
Washington, D C 20006

A final suggestion for keeping costs at a minimum is to contact one or all of the following when you require small amounts of specialized equipment and supplies: nearby universities; community colleges or technical institutes; county health department; regional state water pollution control lab (in N C it's the Board of Water and Air Resources); municipal water treatment plant.

Please refer to the following pages before the start of the course so that necessary equipment, supplies, and materials will be available when they are needed.

Films	. . . . .	1, 30
Equipment and Supplies	. . . . .	Unit I: 14, 16, 18, 20
		Unit II: 33, 69-71
		Unit III: 87-88, 98-105

UNIT I SCHEDULE

Activity I	WHAT IS WATER? Introduction Characteristics, sources, needs of water Film: "Water Famine" (North Carolina State Board of Health)	2 - 3 periods
Activity II	THE HYDROLOGIC CYCLE Research (1-2 periods) Lab and film ("George Washington's River", North Carolina Wildlife Resources Commission) Discussion Quiz	4 - 6 periods
Films	Activity I	"Water Famine", North Carolina State Board of Health-55 minutes Free
	Activity II	"George Washington's River," North Carolina Wildlife Resources Commission-25 minutes Free

To the teacher

The schedule given is for nine periods but it can be adjusted depending on the ability of the students.

SUPPLEMENTS

[illegible] I

1. [illegible] graphy - Hydrolog[illegible]
2. [illegible] and Key

[illegible] II

1. Four Lab Sheets for Hydrologic Cycle
2. Key for Lab Sheets
3. Teacher Instructions for Lab Stations
4. Station Set Up
5. Quizzes and Key

UNIT I PLAN

UNIT I TITLE: WATER, A RENEWABLE RESOURCE (HYDROLOGIC CYCLE)

TIME: 6-9 periods

PURPOSE OR OBJECTIVE

For students to become knowledgeable of the sources of water, of the phases of the hydrologic cycle, and how and why biological and physical forces interact in the cycle. Utilizing the knowledge gained, students will be able to formulate opinions relating to why there is a vital need for quality water.

By performing certain activities students will develop skills in devising, organizing, performing, and analyzing scientific experiments.

ABSTRACT

Through the use of various visual aids (books, tapes, experiments) and discussions the natural functioning of the hydrologic cycle is studied.

The students perform experiments which demonstrate the water cycle. By performing these experiments, students are provided an activity which, even though closely teacher-directed (since it is the first activity in the course) allows ample opportunity for the development of student imagination and analytical ability.

Allow approximately four minutes for all students to write a paragraph explaining why the study of water pollution is important. Students should include information collected above in the paragraph. (This activity is optional.)

Day 2: Film - "Water Famine", 55 minutes, North Carolina State Board of Health
Introduction to the film: This film presents why we have a course called "Water Quality Control". Pay close attention: It is not an enjoyable film. It is the cold, hard truth about the water famine.

Suggested questions for the film

Would we have enough water if the water wasn't polluted?

Why have water problems become so serious?

What are some things that cause the "water famine"?

How can we solve our water problem?

Day 3: Allow students time to research reference materials on the hydrologic cycle. Students should give the following information: title of the book, pages read, notes or a brief summary of the material.

The purpose of the research period is for students to learn about the different phases of the water cycle.

A simple pretest on the hydrologic cycle may indicate "Day 3" unnecessary or needed by only some of the students.

Additional reading requirement: Refer to supplement #2, H_2O and Key

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SUPPLEMENT ...

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WATER

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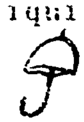
STENCIL

SUPPLEMENT #2

H_2 

H_2O

Riddle: What has no color, no odor, no taste, And is present in this classroom as a solid, a liquid, and a gas?

Answer: An umbrella? Hint: 

The riddle could have also included: what do we clean with, cook with, manufacture with, play with, heat with, grow our food with, remove our wastes with, travel with, light our houses with (figure it out!), and stay alive with?

List uses and misuses

____

____

____

____

____

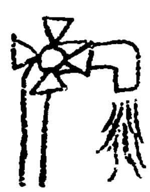
____

____

LET'S FACE IT - there would be NO LIFE on this planet without. . . . water. NO LIFE, . . and still most of us use water without even thinking about where it came from, or where it is going. To prove I'm right, I want you to list all the ways you used water in the past 24 hours (if you can) and all the ways you misused water in the last 24 hours

---

Now - where did that water come from (specifically)



town: ______________________

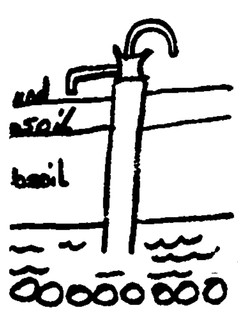
county: ______________________

And - where did the 'used' water go (not "down the drain")

town: ______________________

county: ______________________

Did you know that over 3/4 of the earth's surface is covered with water? But water is also found under the ground. This is called ground water. Rain water sinks into the ground until it reaches a certain level. This level is called the water table. Wells tap this supply of water. In eastern North Carolina the water table comes very close to, or even right up to the surface of the earth. In other words, it's "swampy" around here. How low is the water table where you live? ______________________

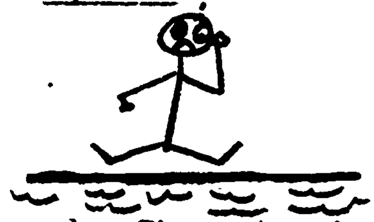


Supplement #2 (Cont.)

How did you find out?____________________________________

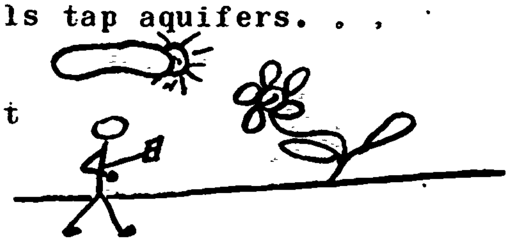
In fact - sometimes the water table is higher than the ground. This forms a ______________.

And did you also know there is a river flowing under you right now? It's called an aquifer.? It flows all the way from the mountains down to the ocean. . . under the ground: pushed by the weight of the soil above it, pulled to lower levels by gravity, and fed by water seeping into the ground.



The water in the aquifer runs through porous rock that actually resembles a sponge in many ways (except it's hard). Wells tap aquifers. . . ask Texas Gulf Sulfur!

What happens to the rain and snow that DON'T seep into the ground to feed aquifers or to form the ground water:



____

____

____

BUT - where does water come from originally -

the clouds?

the ocean?

the rivers?

the ground?

under the ground?

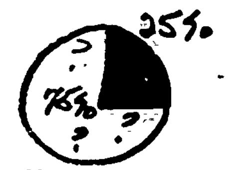
FIVE THOUSANDS YEARS AGO. . .

when the fiery ball of gases was cooling to form our planet, there were billions upon billions of tiny, invisible water molecules forming. Being very light, they mainly stayed as a gas above the heavy metals that were cooling and solidifying to form our "ground". As the earth continued to cool, much of this water vapor or gas condensed to form the first raindrops. And then it rained for thousands - no hundreds of thousands of years! Until the oceans filled and the water flowed from mountain peaks in millions of creeks and rivers.

Always returning to the ocean.

But does every molecule of water that falls as rain return to the ocean? NOT HARDLY!

Only about 25% of all the rain that falls returns to the ocean. So where does the other 75% of the water go?



There are SO MANY intriguing facts to read about water. Yet ONE fact fascinates me particularly. . . and this one fact could spell our doom: FACT The very water YOU brushed your teeth with this morning could have quenched the thirst of a giant dinosaur millions of years ago!!

IN OTHER WORDS

THERE IS ON EARTH RIGHT NOW ALL THE WATER THERE EVER WAS. . . . . AND EVER WILL BE. . . . . . WATER IS NOT BEING MADE - WATER ONLY CYCLES.

Now you explain why this fact may "spell our doom".
(use the back of the paper please)

O.K., it's your turn What one fact about water intrigues you the most? (answer on the back)

SUPPLEMENT #2

Key For H_2O Handout

PAGE 1

Uses of water: produce electricity; wash clothes, dishes, teeth, body, car, etc.; use to heat with; to drink, to cook with; flush the toilet; for transportation; to make paper

Misuses: let faucet drip; let faucet run needlessly; filled bathtub full of water for a bath; used phosphate detergent; washed small loads of clothes; left lights on needlessly (uses electricity which is generated by water)

*Where water comes from: town -
county -

*Where used water goes: town -
county -

*Depth of water table:

How to find out: information available from the local Health Department, county agricultural agent or the Soil Conservation Service

PAGE 2

What happens to rain and snow: evaporates, runoff into streams and rivers, used by plants and animals

Other 75%: evaporates, becomes groundwater, used by organisms, forms lakes, rivers, creeks

Spell our doom: We are adding chemicals that cannot be removed from the water. We are adding too many pollutants too fast (too many cities are making too many demands upon a river or water supply). The water cycle does not cycle fast enough and some pollutants are never removed. We will always have water, but not necessarily usable water!

Fact: Student answers will vary!

*No specific answers are given as they will depend upon your locale.

UNIT I: WATER, A RENEWABLE RESOURCE (HYDROLOGIC CYCLE)

Activity II

The Hydrologic Cycle

TIME: 5 periods

INTRODUCTION

This activity revolves around a lab in which the students will build scientific models illustrating the hydrologic cycle, the method by which water is replenished in nature. Working in groups, students set up the models, answer the questions on their lab sheet, and then explain their model to the whole class.

MATERIALS

Reference books: Refer to supplement #1, Bibliography - Hydrologic Cycle

Lab equipment: Refer to supplement #3 and #4, Lab Sheets and Key

Refer to supplement #5, Teacher Instructions for Lab Stations

Equipment needs vary depending upon the number of groups (the set-up given is based on a class of 25 students)

TEACHER DIRECTIONS FOR HYDROLOGIC CYCLE LAB

Before beginning the experiments it is most helpful if one period is set aside for students to read about or use audio-visual materials relating to the hydrologic cycle. (This research time is not given in the schedule but it can be worked in easily.)

Copies of the experiments are given (supplement #3). The class may be divided into groups or the students may work individually, depending upon available materials and student ability. Each group (or student) would do one of the four experiments. The experiments can also be adapted to form six stations (this is very workable with a large group of students). Instructions for establishing the six stations are given in supplements #5 and #6.

The experiments and questions can be completed in approximately one to one and one-half periods. With less capable and inexperienced students a greater amount of time is necessary, even as much as two periods.

After compiling and organizing their data, each group (or student) should set up their experiment and explain it to the rest of the class. All students take notes: The discussion of the experiments may require from approximately 25 to 55 minutes depending upon student abilities.

SUGGESTED SCHEDULE

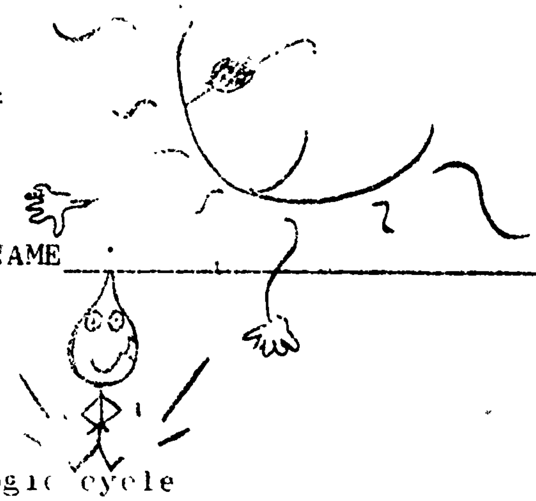
Day 1: Explain the labs to the students. Allow students time to select their experiment and form their groups. If time, students begin working on the labs.

Film - "George Washington's River", 25 minutes, North Carolina Wildlife Resources Commission

Day 2: and 3 Students complete their experiments and organize in preparation for their presentations. The presentations may require a period to complete.

Day 4: In a discussion with the students, determine what renewable resources are and why water is called a renewable resource. Also discuss how the hydrologic cycle provides students' homes with water. A comparison could be made between those students in the class whose water supply comes from wells as to those whose supply comes from the town. A conclusion to the discussion could be a summarizing of all the phases of the water cycle as it occurs in Nature.

Day 5: In conclusion, a quiz may be given (supplement #7).



STENCIL

SUPPLEMENT #3

Lab Sheet

DATE________________________ NAME________________________

COURSE________________________

Experiment 1 - The Hydrologic Cycle

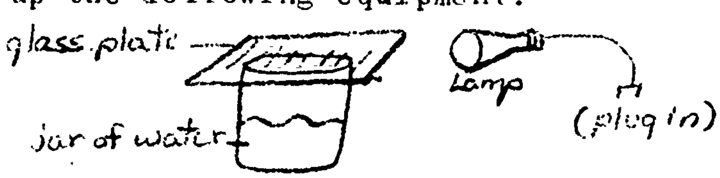
__Purpose__: to demonstrate the role of the sun in the hydrologic cycle

__Materials__

1 bowl or beaker
1 glass plate
heat lamp or 100 W light bulb
water

__Procedure__

Set up the following equipment:



*Note: Do not have the beaker directly under the light.

Record your observations (what you __see__ occur):
Time (glass)______________; Time (droplets)______________

__Discussion__

Explain __what happened__ during this experiment. Be as detailed as you can. Read from the references if necessary. Be prepared to explain this experiment to the class.
*Hint: Write your conclusions on the back!

__GOING FURTHER__

You have made a "model" in the above experiment. The model represents a part of the hydrologic cycle as it occurs in nature, but the model is artificial. Explain what each part of the model actually represents in the outdoor environment.

MODEL		IN NATURE
beaker of water	=	______________
heat lamp	=	______________
droplets of water on glass plate	=	______________
space between plate and water in beaker	=	______________

Supplement #3 (Cont.)

QUESTIONS

1. What do each of the following terms mean. Use your brain and a  !

evaporation ____________________

____

condensation ____________________

____

precipitation ____________________

____

water vapor ____________________

____

2. Describe the hydrologic cycle using the four terms defined in question # 1.

STENCIL

SUPPLEMENT #3

Lab Sheet

DATE________________ NAME________________

COURSE________________

Experiment 2 - The Hydrologic Cycle

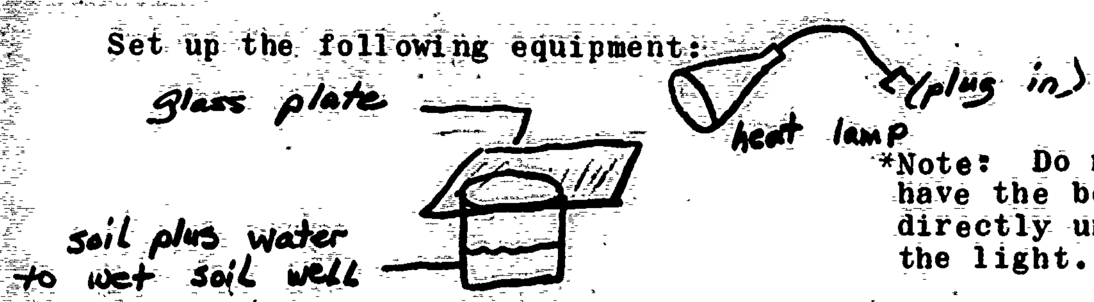
Purpose: to demonstrate the role of the sun in causing the alternate evaporation and condensation of water that takes place on the surface of the ground

Materials

soil	1 bowl or beaker
1 glass plate	heat lamp or
water	100 W incandescent light bulb

Procedure

Set up the following equipment:



*Note: Do not have the beaker directly under the light.

Record your observations (what you see occur):
Time (glass)________________; Time (droplets)__________

Discussion

Explain what happened during this experiment. Be as detailed as you can. Read from the references if necessary. Be prepared to explain this experiment.

GOING FURTHER

You have made a "model" in the above experiment. The model represents a part of the hydrologic cycle as it occurs in nature, but the model is artificial. Explain what each part of the model actually represents in the outdoor environment.

Supplement #3 (Cont.)

MODEL		IN NATURE
beaker of soil	=	______
heat lamp	=	______
droplets of water on glass plate	=	______
space between soil and glass plate	=	______

QUESTIONS

1. What do each of the following terms mean:

   evaporation______

   condensation______

   precipitation______

   water vapor______

2. Describe the hydrologic cycle using the 4 terms defined in question #1.

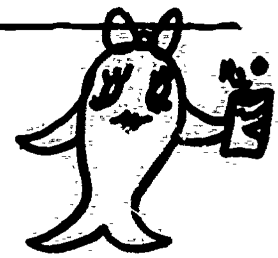
STENCIL

SUPPLEMENT #3

Lab Sheet

DATE____________________ NAME____________________

COURSE____________________



Experiment 3 - The Hydrologic Cycle

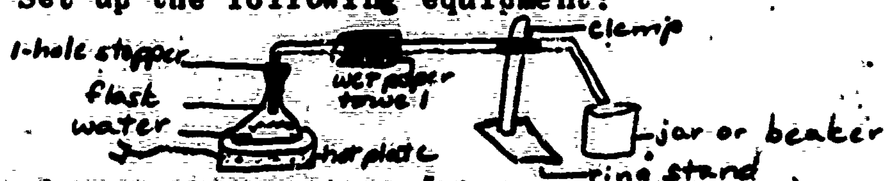
<u>Purpose</u>: to demonstrate the hydrologic cycle

<u>Materials</u>

- 1 flask filled with water and stoppered
- hot plate
- glass tubing
- beaker or jar
- ring stand and clamps
- wet paper towel

<u>Procedure</u>

Set up the following equipment:



<u>Record your observations</u> (what you <u>see</u> occur):

<u>Discussion</u>

<u>Explain what happened</u> during this experiment. Be as detailed as you can. Read from the references if necessary. Be prepared to explain this experiment to the class.

<u>GOING FURTHER</u>

You have made a "model" in the above experiment. The model represents a part of the hydrologic cycle as it occurs in nature, but the model is artificial. Explain what each part of the model actually represents in the outdoor environment.

MODEL		IN NATURE
flask of water	=	____________
hot plate	=	____________
glass tubing	=	____________
collecting jar	=	____________
droplets of water entering jar	=	____________

Supplement #3 (Cont.)

QUESTIONS

1. What do each of the following terms mean:

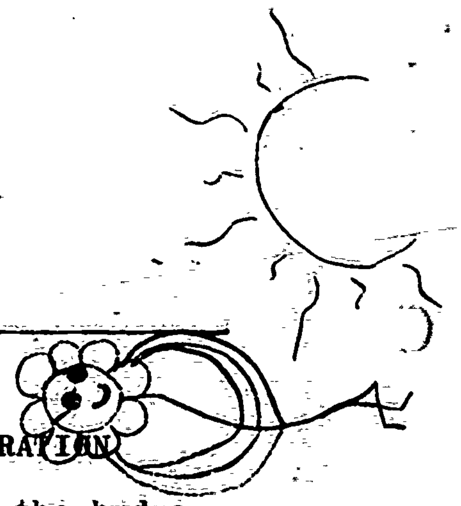
   evaporation____

   condensation_______________________________________

   precipitation______________________________________

   water vapor____

2. Describe the hydrologic cycle using the 4 terms defined in question #1.



STENCIL

SUPPLEMENT #3

Lab Sheet

DATE__________________ NAME__________________

COURSE__________________

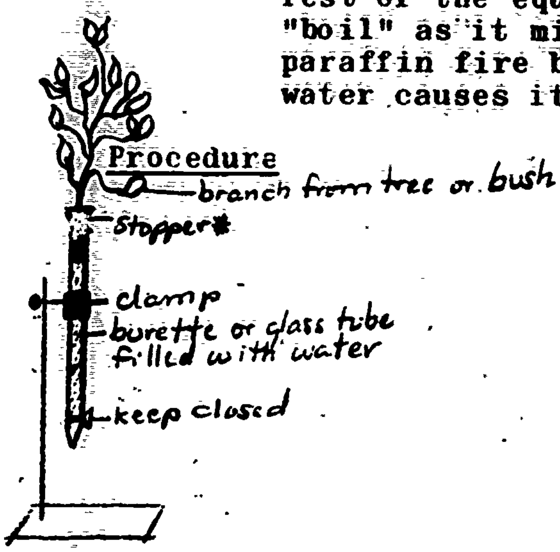
Experiment 4 - Hydrologic Cycle: EVAPOTRANSPIRATION

Purpose: to demonstrate the role of plants in the hydrologic cycle

Materials

1 burette (handle carefully-very expensive)
1 ringstand with burette clamp
water
a twig with leaves
stopper
*paraffin in can)
paint brush) or vaseline
*hot plate)
wax pencil
*Note: First place a beaker of water on the hot plate. Place a beaker of paraffin in the water. Allow the paraffin to melt while you set up the rest of the equipment. (Don't let the paraffin "boil" as it might catch on fire! Extinguish a paraffin fire by smothering, not with water; water causes it to explode!)

Procedure



*Note: insert twig carefully into stopper and seal with melted paraffin (or vaseline) using the paint brush to transfer the paraffin to the stopper. Make sure the end of the twig is at least one inch into the water.

Mark the level of the water at the start of the experiment using the wax pencil. Note the time. ______________

Every 10 minutes mark the level of the water on the burette.

Supplement #3 (Cont.)

Record your observation (what you see occur)

DISCUSSION

Explain what happens during this experiment. Be as detailed as you can. Read from the references if necessary. Be prepared to explain this experiment to the class.

GOING FURTHER

1. Would the hydrologic cycle continue if there were no plants on the earth? (explain)

2. Do animals (including humans) participate in the hydrologic cycle? (explain)

3. Why are plants a part of the water cycle? (explain)

QUESTIONS

1. What do each of the following terms mean:

evaporation____________________

transpiration____________________

water vapor____________________

condensation____________________

percipitation____________________

perspiration____________________

2. Describe the hydrologic cycle using the six terms defined in question #1.

SUPPLEMENT #4

Key For Lab Sheets (Hydrologic Cycle)

EXPERIMENT #1

<u>Observation</u>: Time (glass) <u>varies</u> ; Time (droplets) <u>varies</u>
The sides of the beaker and the glass plate will become "cloudy", but not if the beaker is too close to the light.

<u>Discussion</u>: The heat from the lamp causes the water in the beaker to evaporate. When this water vapor hits the cool glass, it condenses. If the lamp is too close, the lamp stays hot and the water remains as a vapor or gas.

<u>Going Further</u>:

MODEL	IN NATURE
beaker of water	represents a lake, river, mud puddle, a pond, or the ocean
heat lamp	represents the sun
droplets of water on the plate glass	represent clouds or rain
space between plate and water in beaker	represents the atmosphere

<u>Questions</u>

1. Definitions

<u>Evaporation</u> is the change in state of a substance from a liquid to a gas.

<u>Condensation</u> is the change in state of a substance from a gas to a liquid.

<u>Precipitation</u> is falling moisture such as rain, sleet, snow, or hail.

<u>Water Vapor</u> is water existing as a gas in the atmosphere.

2. Explanation of the hydrologic cycle

condensation

water vapor

evaporation (caused by sun)

body of water

Supplement #4 (Cont.)

Water evaporates from the ground or bodies of water. It rises, cools, and condenses on particles in the air. Under certain conditions water precipitates. There is always invisible water vapor present in the atmosphere.

EXPERIMENT #2

Observation: Refer to experiment #1 as the results are similar.

Discussion: Refer to experiment #1 as the results are similar.

Going Further

MODEL	IN NATURE
beaker of soil	represents the soil or ground

Refer to experiment #1 for the other answers as these are the same.

Questions

1. Definitions

   Refer to experiment #1 as the answers are the same.

2. Explanation of the hydrologic cycle

   Refer to experiment #1 as the answers are the same.

EXPERIMENT #3

Observation: The water boils in the flask; steam rises, runs through the tube and droplets of water enter the beaker

Suggestion: Have the students add a dye (methyl orange, methylene blue, cake coloring) to the flask. Tell the students this colored water represents polluted water. Next, ask the students what effect might the polluted water have on the hydrologic cycle, and can the cycle always remove the pollutants.

Discussion. The heat causes the water in the flask to evaporate and move through the tube; as the water cools in the tube, it condenses and falls, as "rain", into the beaker

Supplement #4 (Cont.)

Going Further

MODEL	IN NATURE
flask of water	represents any body of water
hot plate	represents the sun
glass tubing	represents the atmosphere
collecting jar	represents the land (earth)
droplets of water entering the beaker or jar	represents rain

Questions

1. Definitions

   Refer to experiment #1 as the answers are the same.

2. Explanation of the hydrologic cycle

   Refer to experiment #1 as the answers are the same.

EXPERIMENT #4

Time: Answers will vary.

Observation: The water level should drop.

Discussion: Water is being absorbed by the plant stem. It evaporates through the openings of the leaves. The evaporation of the water is speeded up by the fan blowing on the plant.

Going Further:

1. Yes, the cycle would continue because water would still evaporate from the ground and bodies of water. The cycle would probably begin to slow down and at certain points become blocked.

2. Yes, we participate in the cycle by the intake of water into our bodies and also by the elimination of water from our bodies through perspiring and urinating.

3. Plants absorb and release water to the atmosphere helping to keep a more even balance of water and thereby aiding the flow of water in the cycle.

Supplement #4 (Cont.)

Questions

1. Definitions

   Refer to experiment #1 as the answers are the same except for these additions:

   Transpiration is the loss of water vapor from a plant.

   Perspiration is the loss of water vapor from animals such as man.

2. Explanation of the hydrologic cycle.

   Refer to experiment #1 as the answer is the same except for the addition of the following statement: The water which falls upon the ground is absorbed. This water in turn may be absorbed by plants, used, and released through transpiration. Animals, such as man, also take in water and eliminate it either by perspiring or as urine.

SUPPLEMENT #5

Teacher Instructions For Lab Stations

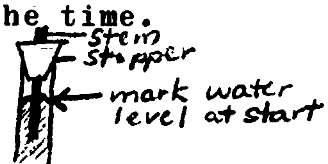
INTRODUCTION

Setting up the lab requires approximately 30 to 45 minutes. Student completion of the lab is facilitated by establishing stations as illustrated by supplement #6. At each of the stations it is most helpful to have instructions written to the student. Suggested student instructions are given below for each station.

SUGGESTED STUDENT INSTRUCTIONS

Station I: Do experiment #1. The equipment is on the A-V cart (put the equipment back as you found it). Figure out a way to suspend the light. Note the time you put the glass over the beaker and the time when droplets begin to form on the glass. Record these times on your lab sheet.

Station II: Do experiment #4. The equipment is on the A-V cart (put the equipment back as you found it). Direct the fan onto your equipment. Put a piece of masking tape on the burette and mark the water level at the start of the experiment. Record the time. Also mark the water level at the end of the experiment. Record the time. Measure the distance between the two marks:



The stem of the plant <u>must be about one inch</u> into the water.

Station III: Do experiment #1, <u>but</u> do not use the light! The equipment is on the lab cart (put the equipment back exactly as you found it). Note the time you put the glass cover over the beaker and the time when droplets begin to form on the glass. Record these times on your lab sheet.

Station V: Do experiment #2. The equipment is on the lab cart (put the equipment back exactly as you found it). Take your model to Station #I so you can use the light. Note the time you put the glass over the beaker and the time when droplets begin to form on the glass. Record these times on your lab sheet.

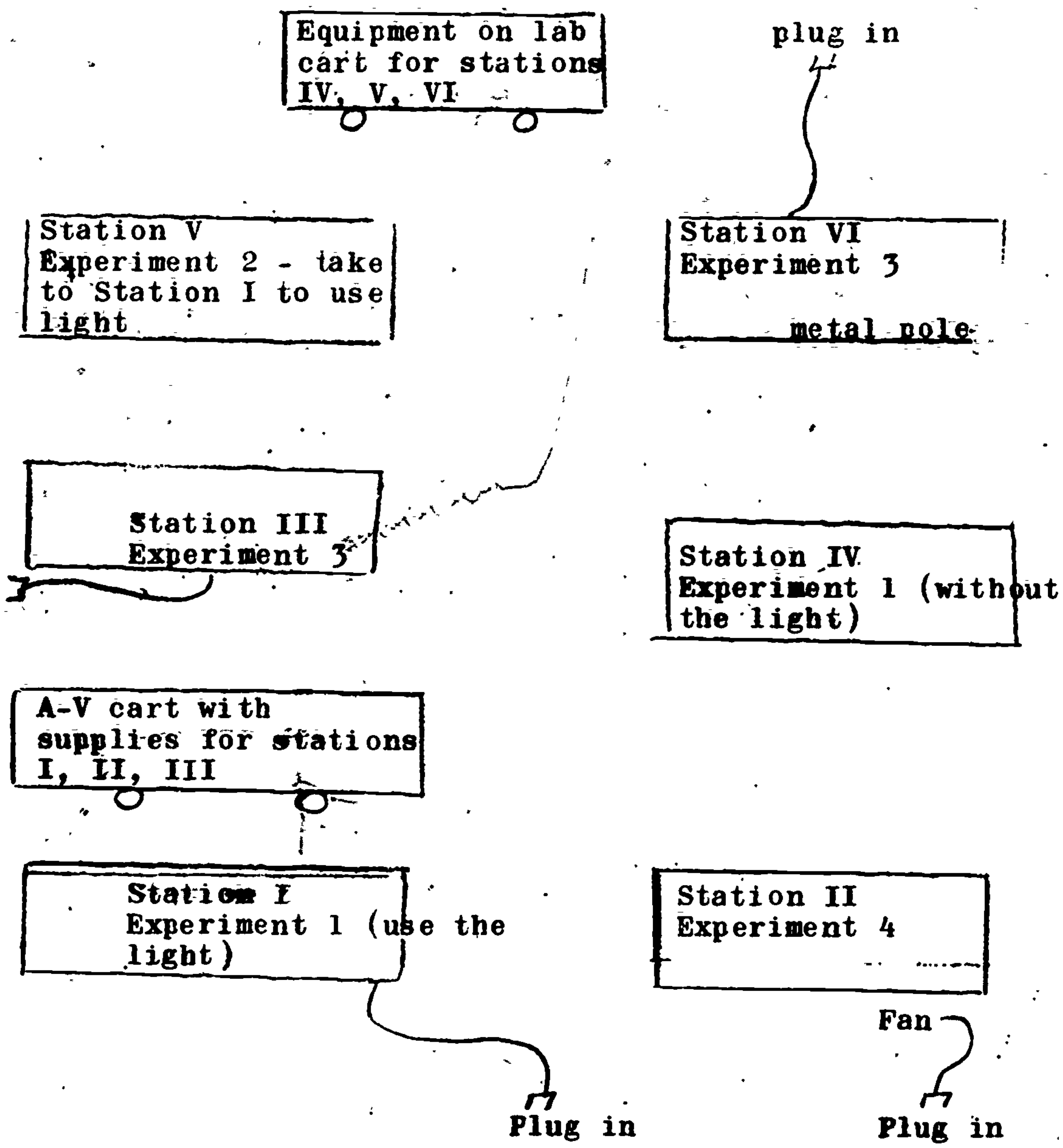
Station VI: Do experiment #3. The equipment is on the lab cart (put the equipment back as you found it).

SUPPLEMENT #6

Station Set-up

Before class

1) Place directions for each station on the tables (refer to Supplement #5)
2) Place equipment on A-V cart (two carts are <u>not</u> necessary!)



STENCIL

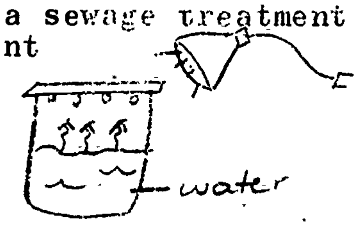
SUPPLEMENT #7

Quizzes and Key

Quiz A: Hydrologic Cycle

Questions:

1-3: List three uses of water.
4. If you live in the county (in the country) where does your drinking water come from?
5. If you live in the city where does your drinking water come from?
6. Used water or waste water in the (county, town) goes to a sewage treatment plant after being used.
7-10: Experiment



7. What natural process does the diagram above represent?
8. Why is the lamp necessary?
9-10: List two ways you could "block" this natural cycle.
11-15: Make a drawing of the water cycle. Label each of these phases:
    11. evaporation
    12. condensation
    13. precipitation
    14. run-off
    15. ground water
16. In the above drawing show how man becomes a part of this natural cycle.
17. Tell the function of each in the water cycle:

17. a cloud	22. an aquifer
18. a green plant	23. rain
19. a cow	24. a sewage treatment plant
20. the sun	25. soil (the ground)
21. a creek	

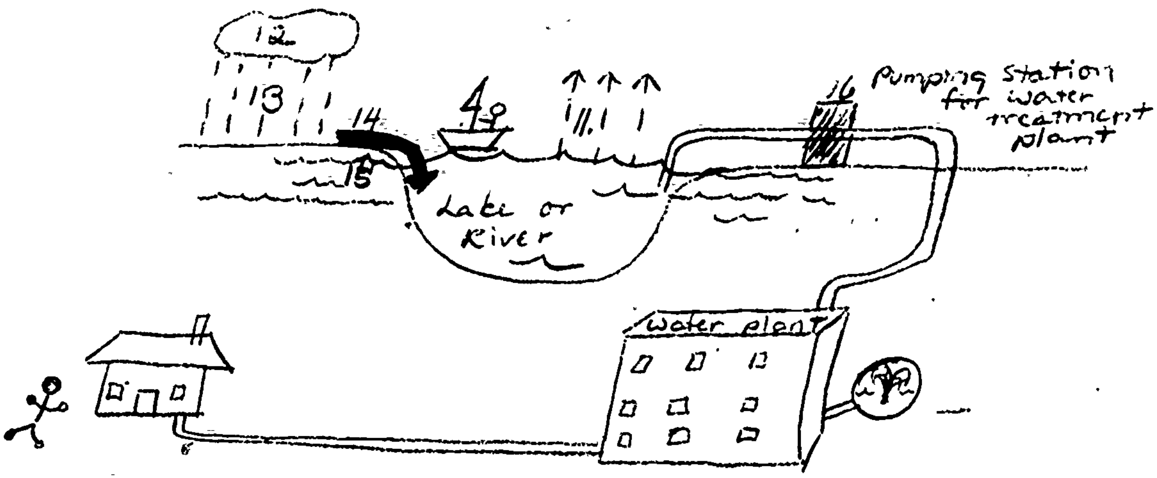
Quiz B: Hydrologic Cycle

Directions for the teacher: Each student draws a picture that shows the parts of the water cycle. Each part should be labeled, such as evaporation, condensation, etc. (refer to Quiz A, questions 11-15, and 16). An alternative would be for each student to be given magazines, scissors, glue, cardboard, and instructed to glue cutouts on a piece of cardboard to illustrate the water cycle. Students could work in groups.

SUPPLEMENT #7

Quiz A Key

1-3. to cook with, bathe, to drink, for agricultural uses, recreation, a means of transportation, etc.
4. groundwater or well
5. Tranters Creek
6. town
7. water cycle (evaporation, condensation)
8. sun or energy source
9. remove or block out light (block out the sun's rays)
10. increased amounts of pollutants in the water source and atmosphere might block the system
11-16. diagram such as the one below -



17. condensation
18. evapo-transpiration
19. takes in, uses, and eliminates water from the body
20. energy source
21. collects and stores water
22. underground source of fresh water
23. precipitation
24. purifies waste water
25. absorbs and stores water

UNIT II SCHEDULE

Pre-Activity	HOW DOES WATER BECOME POLLUTED Location of polluters Research Lecture and project assignment Game: Problems from water pollution	4-5 periods
Activity	HOW ARE POLLUTANTS REMOVED FROM WATER Introduction Lab experiments Discussion	$2\frac{1}{2}$ periods
Post-Activity	MUNICIPAL SEWAGE TREATMENT Field Study Discussion	3 periods
Films	Pre-Activity	"The River Must Live", Shell Oil Company 21 minutes Free "Health and the Water Cycle", North Carolina State Board of Health 20 minutes Free

To the teacher

The schedule given is for ten and one-half periods but it can be adjusted depending on the ability of the students.

SUPPLEMENTS

Pre-Activity
8. Pollution Cut-outs
9. Bibliography - Pollution: Scientific
10. Water: Elixer of Life or Poison and Key
11. Brain Drain
12. Key Words and Quiz
13. Film Review - "The River Must Live"
14. Game Problems and Clues
15. Teacher Information Chart for the Game

Activity
16. Stations for Water Purification Lab and Diagram
17. Student Directions for Purification Lab

Post-Activity
18. Municipal Water Treatment
19. Six Weeks Exam, Answer Sheet and Key

UNIT II PLAN

UNIT II TITLE: IS WATER A RENEWABLE RESOURCE?

TIME: 6 to 9 periods

PURPOSE OR OBJECTIVE

For students to become knowledgeable of the sources of water pollutants and the effects of these pollutants on living organisms and the hydrologic cycle.

For students to become knowledgeable of how water purifies itself naturally; of how water pollutants may be removed artificially, and concurrent with gaining this knowledge, for students to learn that dilution does not always eliminate the problems caused by some pollutants.

ABSTRACT

The pre-activity is designed to make students aware of the many kinds of water pollutants: where they originate, how they enter the water, and the effects these pollutants have on the natural environment. A model of a polluted river is constructed. The main activity involves various attempts to remove the pollutants from this polluted river. The post-activity is a visit to the Municipal Sewage Treatment Plant to learn the methods employed by your own city to eliminate pollutants from water.

UNIT II: IS WATER A RENEWABLE RESOURCE?

Pre-Activity Plans

How Does Water Become Polluted?

TIME: 5 periods

SUGGESTED ACTIVITIES

Day 1: This part of the pre-activity is designed so that students will begin to locate sources of water pollution.

The day prior to this pre-activity, hand out copies of a town such as the one attached. For homework the students can list on the back all the polluters they see in the diagram.

Instructions: Before class, sketch the outline of the town, fields, rivers, etc. on the board. On a front table have the following:

a. a large mayonnaise jar (approximately one gallon) or aquarium filled with tap water and labelled "river" (if possible have a different jar for each class)
b. a small dish of sand or soil
c. inorganic trash
d. a dropper bottle of methylene blue or other biodegradable dye
e. a dropper bottle of milk
f. a dish of organic garbage
g. detergent
h. a small dish of fertilizer pellets (or a dropper bottle of liquid fertilizer)
i. a small jar or beaker of tap water for each creek and drainage ditch presented in the sketch and labelled "creek or drainage ditch"
j. a dropper bottle of gasoline
k. a pile of leaves and stems
l. a dish or iron filings or any other metal

During class pass out the cut-outs of the polluters (the bulldozer, house, boat, car, etc. - refer to supplement #8). The students are instructed to come up one-at-a-time and tape their cut-out onto the board in a logical site (the student may follow the model town or inject his own idea of the location of the polluter). Next the students explain how their item pollutes. On their way back to their s--t, the students go to the table of pollutants and add a sample of their pollutant(s) to the river and/or creek. Allow each student approximately one minute to present the information about his polluter. After all students have given their presentations, pour the "creeks" and "ditches" into the river. A heated discussion is certain to follow. To stimulate, responses pose a question such as: Is this our town's river?.

A suggested follow-up would be to write all the polluters students have identified on the board and request the students to record these in their notebook. Some terms to bring out are as follows: polluter, pollutant, sludge, effluent, sewage, organic waste, nutrients (phosphates, nitrates), eutrophication, biodegradable, dilution, concentration.

After class don't pour out the "river" since it is used in the activity, How Pollutants are Removed, and in practice for the fecal coliform test.

Day 2 and 3: Students spend the period researching available reference materials. Each student could be given a copy of a bibliography (supplement #9). The purpose of the student research is for students to determine the dangers of water pollution. As they read, the students should try to learn as much as possible about the following pollutants: phosphates, nitrates, DDT, mercury, fertilizers, pesticides, siltation, radioactive wastes, oil spills, and lack of oxygen in the water. Request students to find any information which will explain (a) the dangers of the specific pollutant; (b) how to test water samples for the presence of the pollutant; (c) possible ways of removing the pollutant from the water (or environment).

Sometime during the two periods, the students may be given supplement #10, Water: Elixer of Life or Poison; supplement #11, Brain Drain (optional); supplement #12, Key Words and Quiz.

Films - "The River Must Live", 21 minutes, Shell Oil Company (Any film of a similar topic may be shown in place of this film. Refer to supplement #13 for a review.)

"Health and the Cycle of Water", 20 minutes, North Carolina State Board of Health (Any film of a similar topic may be shown in place of this film. The use of this film is optional.)

Day 4: The students have spent approximately one and one-half periods to two periods researching the effects of various pollutants on the water cycle and man. As a follow-up to this, one of the following activities (or both) may be done:

Suggestion #1: Lecture and demonstrations - the effects of pollutants on the water cycle and organisms

Topics to discuss:

1) a definition of water pollution
2) the effects of various pollutants on the water cycle e.g. DDT co-evaporates with water and isn't removed from the environment; air and land pollutants wash into waterways and seep into the groundwater supply
3) the effects of various pollutants on organisms; points to discuss are dilution; concentration, via a food chain

Other topics to discuss:

Chemicals

To demonstrate that chemicals like lead, DDT, and mercury can be dangerous even in small quantities, add iron filings to a beaker of water. The iron filings represent DDT or any heavy metal. A magnet suspended on a string can be floated in the water to represent a fish. The fish concentrates the DDT by feeding. To extend the concept, another larger magnet can be suspended to pick up the small magnet. This can lead into a discussion of the effects on higher carnivores.

To demonstrate that chemicals can be present in water even though often invisible, place a beaker of tap water and a beaker of glycerine on display. Ask the students to decide which is water, or if both or neither are water. After the students have made a decision based only on their senses of sight and smell, pour the water into the glycerine. This should spark a discussion.

Another possible way to demonstrate that chemicals can be present in water, even though invisible, and also may be quite poisonous is to add something very toxic like mercuric chloride to a glass of water. Ask the students to decide between this glass and a similar glass of water as to which, if either or both, is water. Allow the students to make their decision based on the senses of sight and smell.

Fertilizers
Discuss fertilizers as nutrients in water and their role in eutrophication.

Organic wastes and chemicals that consume oxygen
To demonstrate that organic wastes and chemicals consume oxygen, simply display a jar of spoiled milk which will indicate bacterial decomposition and it's concomitant odors. Discuss the effects of excessive use of biodegradable materials in water.

Non-biodegradable materials or substances
To stimulate discussion pose a question such as: What happens to such things as heavy metals, detergents, pesticides, etc., that get into bodies of water.

Pathogenic bacteria and viruses
Discuss diseases such as hepatitis, polio, typhoid fever, flu, cholera, etc., that result from drinking water contaminated by human sewage.

Siltation
Discuss how siltation can block out light; how it occurs; effects of, such as clogging of fish gills, obstructing visibility so that organisms cannot feed, burying of spawning grounds and food; causes of, such as soil erosion, urbanization (construction sites), channelization, dams, thermal pollution.

Radioactive wastes
Discuss how radioactive wastes get into the food chain and possible effects of these (such as death, genetic damage) on organisms.

Oil spills
Discuss the effect of oil spills (such as death to the organisms and blockage of light rays) on water sources.

Conclusion
Now is an ideal time for each student to undertake a project. Preferably, each student will select a water problem which exists at or near his home to study and ultimately try to eliminate. Instruct each student to post a description of his project on a chart in the room or submit a written description. Also the student will be expected to report orally for one minute and write on the chart every two to three weeks concerning his progress. The information on the chart could be:

Name	Problem	Action	Date	Results to Date

Naturally the students will need some suggestions to get them thinking. Some suggested student projects are as follows:

1. "Adopt" a ditch or portion of a creek and clean it up. Plant grass along the banks to prevent erosion. Talk to people who live near the creek and get them to help.

2. Obtain literature from "Keep America Beautiful". It has many project ideas in it.

3. Go to a local grocery and ask the manager if signs which teach how to prevent water pollution could be displayed in the store. For example, by the detergents you would have a sign warning against the <u>over-use</u> of phosphate detergents.

4. Request your local grocery store manager to stop selling colored tissues and not buy plastic fruit bags. Think of ways that would encourage the manager to respond to your request. Check to see if your request is fulfilled.

5. Write a play about a specific environmental problem such as water pollution. Relate the happenings to situations or conditions existing in your town. Present the play to another class or an organization.

6. Make and broadcast a radio or T.V. commercial.

7. Have an "education campaign" to teach the people in your neighborhood about some way they can help fight water pollution. You can conduct your campaign using posters, going door-to-door, talking to people, setting up an information booth in the local shopping center, and writing articles for the local newspaper. Some ideas to teach are: careful use of detergents; minimum use of cars; anti-litter; plant a tree; sparing use of insecticides; additional ideas can be obtained from "Everyman's Guide to Ecological Living" by Cailliet, pgs. 45 - 52, 64 - 68, 73 - 95.

Suggestion #2: Problems From Water Pollution (a game)

Before class write each of the main problems (six) on cards approximately $8\frac{1}{2}$" x 11". The clues can be placed on much smaller cards thereby distinguishing them from the problems. Refer to supplement #14 and #15 for the necessary information. Place the following chart on the board. Students will complete the chart during class (refer to supplement #15):

Problem	How it arises	Test for	Solution to (or how to eliminate it)

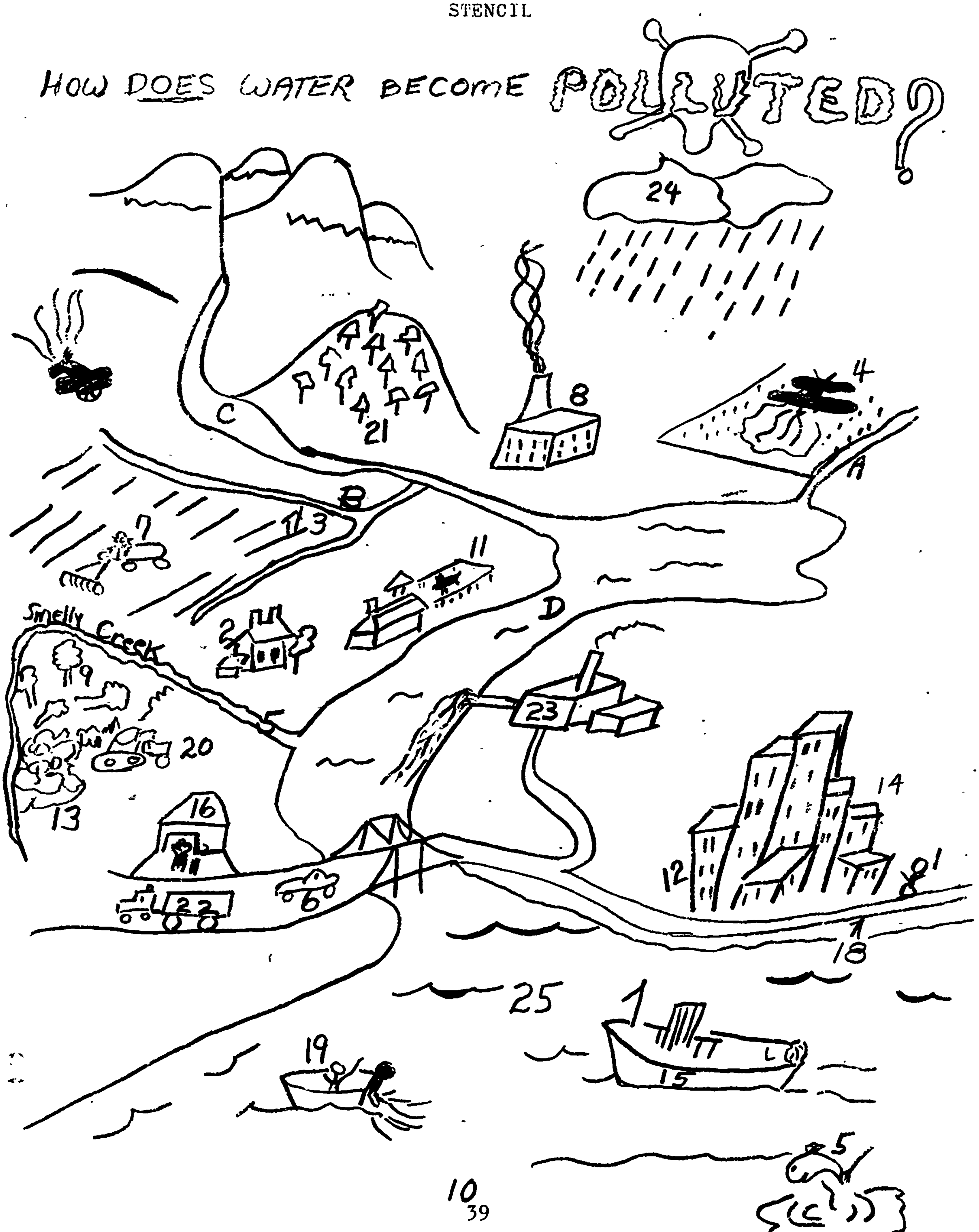
*Reference books should be made available for student use.

Place each of the six main problems on a table or desk in the room so that they are very noticeable to the students.

As the class begins hand each student a clue and briefly explain that located on several tables are six main problems resulting from water pollution. Also explain that each student has received a piece of the whole story that leads to the problem. Instruct the students to take their clue to the table that represents the problem his clue fits. Using all the other clues at his table, the student and his partners should complete the chart that was placed on the board before class. The reference books should be pointed out so that the students will use them if necessary in completing the chart.

After each group has completed all the information on the chart for their specific problem, have each of the six groups present their information to the class (placing the information on the overhead or board as given). This should certainly lead into an interesting discussion with both the teacher and other students offering additional comments to each presentation (refer to supplement #15).

STENCIL


HOW DOES WATER BECOME POLLUTED?
24
4
8
A
C
21
B
3
7
11
D
Smelly Creek
2
9
5
20
13
23
14
16
12
22
6
18
25
1
19
15
5

KEY

A, B, C, D, E - Ditches or Creeks

1. people
2. house
3. outhouse
4. cropduster
5. fish
6. car
7. farmer
8. factory
9. trees
10. plankton (bacteria)
11. cow
12. restaurant
13. dump
14. laundromat
15. oil tanker
16. gas station
17. barn
18. street
19. motorboat
20. bulldozer
21. park
22. diesel truck
23. sewage plant (treatment)
24. cloud
25. algae

Directions: Referring to the diagram "How Does Water Become Polluted?", explain below how <u>each</u> of the above contributes to water pollution.

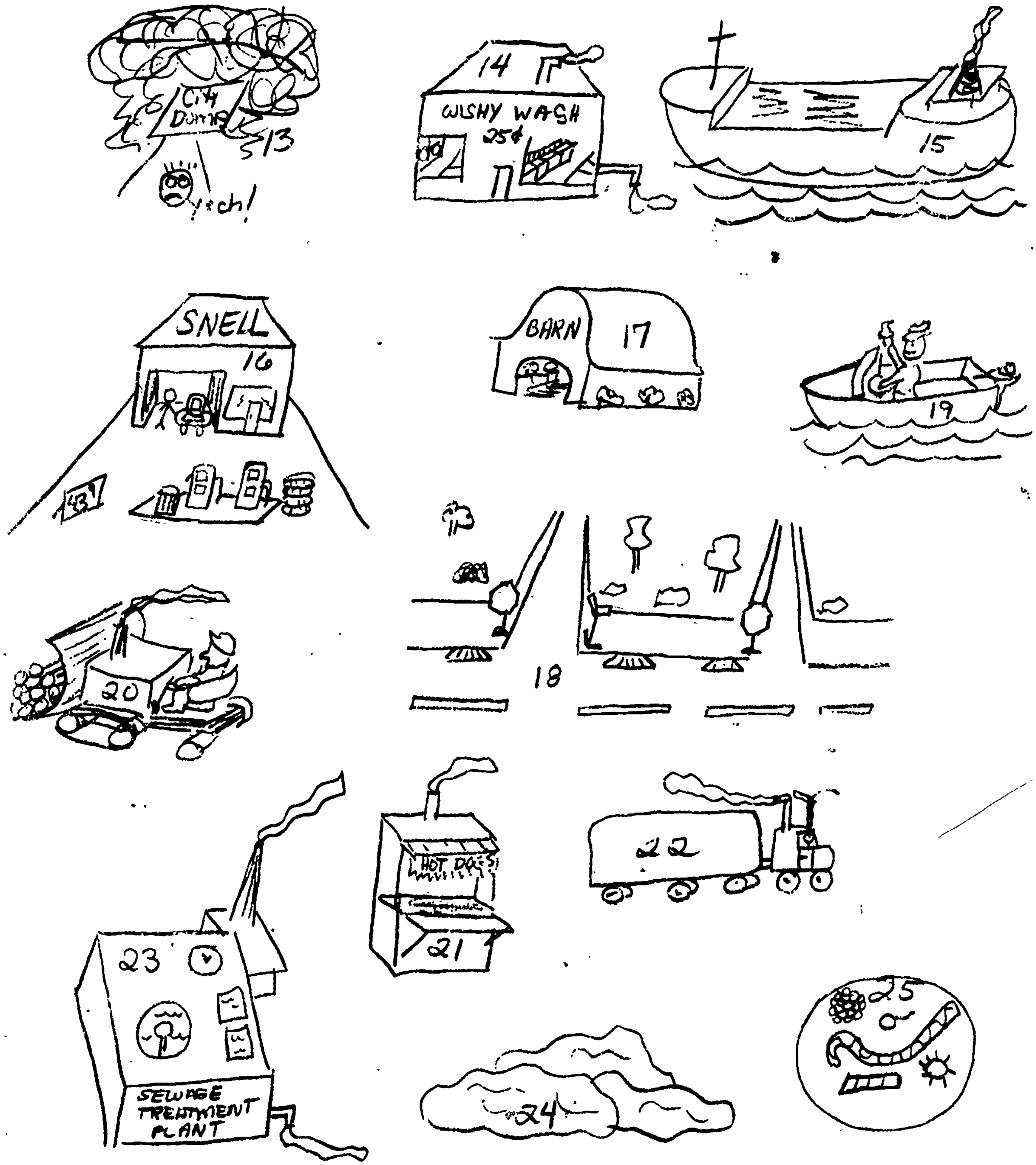
SUPPLEMENT #8

Pollution Cut-Outs

To the Teacher

The diagrams can be traced on a transparency and then blown-up with an overhead projector. Coloring the cut-outs makes them even more effective. The numbers refer to the items listed on the map.

Supplement #8 (Cont.)



STENCIL

SUPPLEMENT #9

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Supplement #9 (Cont.)

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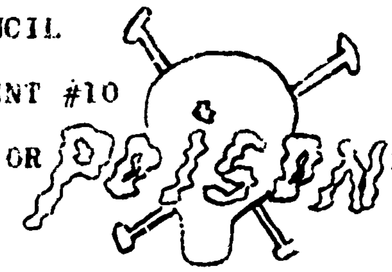
STENCIL

SUPPLEMENT #10

WATER: ELIXER OF LIFE.... OR



Name:_______________
Period:______________

- In America, there are 7000 or more of us taking a bath and flushing the toilet today, than there were just yesterday -

YET

- the same amount of water flows down our streams ...

AND WHAT'S WORSE

- our way of life demands more and more water and pollutes more and more ---

Here is a list of water demands - circle those that are a part of your life: (add some of your own)

to carry off sewage	to cool engines
to drink	to manufacture goods
to cook with	to clean with
to swim and boat in	for swimming pools
to produce electricity	to water flowers and lawns
to heat with	for garbage disposals
for livestock needs	for washing machines
for dishwashers	________________
________________	________________

And here is a list of water pollutants - circle those that are a part of your life ------

NUTRIENTS- mainly phosphates and nitrates from sewage, industry, run-off
CHEMICALS- from detergents, pesticides, herbicides, industrial wastes
OILS- from ships, drill rigs, industry, local auto service stations, streets
ACIDS- from mines and industry
SILT, SAND, DEBRIS- from sidewalks, streets, construction sites, farm erosion, dredging channels
HEATED WATER- from power plants, industrial process
DISEASE-CAUSING BACTERIA, VIRUSES- mainly from domestic sewage
RADIOACTIVE WASTES- from mining and processing radioactive ores, nuclear power plants, from fallout after weapons testing
HEAVY METALS- from fertilizers and industry (like mercury, lead)

Supplement #10 (Cont.)

THE PROBLEM IS: WE don't take the responsibility for cleaning up our messes.
WHY do you think we don't? ______________________________

____

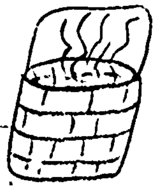
DID YOU REALIZE THAT ⟶ land pollution and air pollution finally end up in our waters?

explain how: land ______________________________

____

air ______________________________

____



(if you drink water from your own well, don't be so smug---ground water also gets pollutants from the land and air)

IT'SSOoooo COMPLICATED.

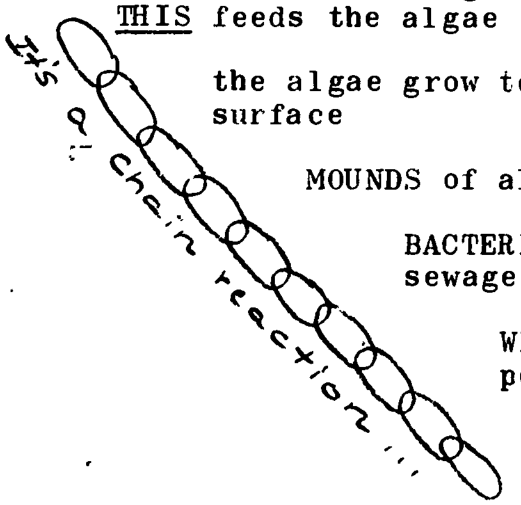
some communities don't even have waste treatment plants--
and some industries don't either ---

most treatment plants aren't good enough-----
pesticides, viruses, and many chemicals cannot be removed by any known treatment ANYWAY

Psst. . . .do you know what eutrophication is????
this wise owl says you should because it's what's happening in the Pamlico River RIGHT NOW (the Chowan River had this to happen to it)

EUTROPHICATION (U-TRO-FI-KA-SHUN) is the process by which a body of water "dies"

AND THIS IS HOW IT HAPPENS: Nutrients (like phosphates and nitrates from sewage and fertilizers) get into the water



THIS feeds the algae (water plants often called scum)

the algae grow too much and cover the water's surface

MOUNDS of algae will die and sink

BACTERIA feed on the dead algae (and the sewage and farm run-off)

WITH ALL THAT FOOD, bacterial populations skyrocket

THESE bacteria use up all the oxygen in the water (they're breathing)

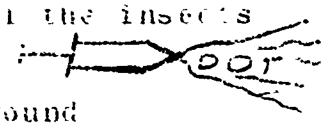
Supplement #10 (cont.)

SOoooo
the fish die
the water stinks
the river (lake) is
DEAD........

IF YOU THOUGHT THAT WAS COMPLICATED, READ ON (PLEASE)...

This is the story about DDT, not Danny Daves Trio, but a DEADLY PESTICIDE

Farmer Wills sprays his cotton with DDT to kill the insects



IT RAINS
THE WATER rinses the DDT into the ground
THE SOIL AND DDT wash into the ditch

THE DITCH empties into the river
THE RIVER empties into the ocean

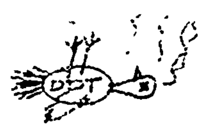
PLANKTON (tiny plants) eat the DDT and die

– Fish eat the plankton –

BIRDS eat the fish

WHEN the birds lay eggs

THE eggs don't ever hatch



THE birds become EXTINCT

here's the real twist. since there are no birds left to eat the insects, what happens?
(see bottom of the page for answer)

NOTE: Two facts make matters worse. . . . no three facts:
1. DDT evaporates with water and rains back down with water, so it (DDT) keeps cycling.
2. DDT can last for many years and nothing decomposes it.
3. The plankton that are killed by DDT in the ocean produce most of the earth's oxygen (during photosynthesis).

So what will eventually happen to us humans? ________________

____

*ANSWER: the insects multiply like mad and eat up Farmer Will's cotton.

Supplement #10 (Cont.)

Want to learn more about water pollution? I hope so. It's like learning how to save your own life.

How can you learn??? Use your bibliography (Pollution - Scientific). In this there are listings of many books, film-strips, tapes, and records.

Be observant! Search your neighborhood for possible sources of pollution.

In the Bible there is a very ominous warning:
"Whatsoever that man soweth. . .that shall He Also Reap".

What special meaning does that warning have for us today?

____

____ (will it be)

THE END

SUPPLEMENT #10

Key for Water: Elixer of Life. . .or Poison

PAGE 1

Why do you think we don't? too busy; too expensive; too lazy; won't be around to see the disaster; not "my fault" attitude; cheaper to leave it there (for the moment); just doesn't seem important

Explain how: land: when it rains runoff water picks up pollutants; soil erosion adds pollutants, as do wind storms

air: when it rains pollutants fall with the water; windstorms carry pollutants to bodies of water

PAGE 3

What will happen to us? might die from lack of oxygen caused by death of plankton; too much DDT may concentrate in our bodies

What special meaning: We shall eventually suffer the consequences of our environmental actions.

STENCIL

SUPPLEMENT #11

Brain Drain

Name: ______________________

"Brain Drain"

We've identified possible polluters. Now we want to learn what the "dangers" from these polluters' pollutants are.

1. A water ____________ of 212°F. is too hot for most organisms to live in.

2. Water animals will die if they do not get enough of this essential element: ______________.

3. ________________ such as typhoid fever, polio, cholera are caused when sewage from sick people enters a water supply.

4. A lack of oxygen in the water may be caused by too many ______________ being present.

5. Scientists know disease-causing organisms are present in water when they count the number of fecal ______________ bacteria.

6. Diseases such as ________________, typhoid fever, flu, ______________ are caused by human sewage being placed in water supplies.

7. ______________ and ________________ are two chemicals present in sewage and fertilizers that feed algae causing algal blooms.

8. ______________ ________________ (overpopulation of algae) results in a lack of oxygen in waters (rivers, creeks, etc.).

9. Water supplies can become too hot when ______________ or power plants release their water directly into a river.

10. ________________________ occurs when too many nutrients like phosphates and nitrates are present.

11. Pollutants like DDT, lead, and mercury poison plants and animals (and are so dangerous in the environment) because when eaten or absorbed the pollutants ________________ in the bodies of the plant or animal.

Supplement #11 (Cont.)

12. Water supplies may become too ________________ when mines and industries dump their wastes into the water.

13. The ____________________ of water is acidic when it is below 6.5.

14. ________________________ is another term for cloudy (light cannot seep through the water).

15. Pesticides, heavy metals, DDT are ____________________.

16. ____________________ ________________ ____________________ generate much heat, raising the temperature of the water supply very, very high.

17. ____________________ and farm run-off often make water supplies very cloudy or ____________________.

18. Another term for water which can be drunk is ___________ water.

19. Overheating of a body of water by industries dumping water from their cooling systems is ________________ pollution.

20. _________________ are tiny plants which live in water and which when huge overgrowths occur in water supplies use up our oxygen.

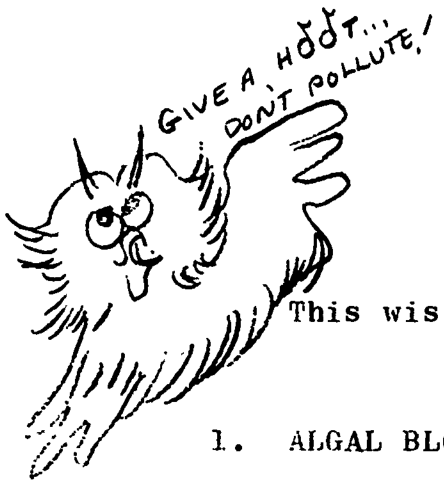
This wise owl says: Use your vocabulary words, bibliography, and the following choices to find the answers.

1. oxygen
2. diseases
3. eutrophication
4. turbidity
5. atomic power plants
6. coliform
7. temperature
8. soil erosion
9. thermal
10. bacteria
11. algae
12. polio
13. nitrates
14. industries
15. concentrate
16. acidic
17. pH
18. potable
19. algal bloom
20. toxic
21. phosphates
22. cholera
23. turbid

Supplement #11 (Cont.)

To the teacher

The answers to the questions are as follows:
(1) temperature; (2) oxygen; (3) diseases; (4) bacteria; (5) coliform; (6) polio and cholera; (7) nitrates and phosphates; (8) algal blooms; (9) industries; (10) Eutrophication; (11) concentrate; (12) acidic; (13) pH; (14) Turbidity; (15) toxic; (16) atomic power plants; (17) soil erosion, turbid; (18) potable; (19) thermal; (20) algae



STENCIL

SUPPLEMENT #12

Key Words

Name:________________

This wise owl says: If you want to help clean up and protect our waters you'll learn these words:

1. ALGAL BLOOM: huge overgrowth of algae that has been fertilized by sewage and farm fertilizers

2. ALGAE: tiny plants that live in the water

3. BIODEGRADABLE: can be decomposed

4. COLIFORM BACTERIA: bacteria present in sewage

5. EFFLUENT: the liquid that's left after sewage is treated

6. EROSION: removal of soil and pollution by rainwater ---- often ends up in the water

7. EUTROPHICATION: algal blooms, loss of oxygen, and consequent death of a body of water

8. MUNICIPAL SEWER: city pipelines that carry sewage to the treatment plant

9. MALODOROUS: has a foul smell

10. NOXIOUS: harmful, irritating, annoying

11. NITRATES; PHOSPHATES: two chemicals present in sewage, fertilizers, and detergents that feed algae and cause them to overpopulate

12. ORGANIC: substances (like food particles, wood) that can be decomposed (decayed) by organisms feeding off it

13. POLLUTION: contamination that upsets the natural balance

14. POLLUTANT: something that contaminates

15. PATHOGENIC BACTERIA: disease-causing bacteria

Supplement #12 (Cont.)

16. pH: a term used to describe how much acid or base a liquid has--a pH of 6.5 to 8 is best for most organisms; below 6.5 is too acid; above 8 is too basic

17. POTABLE WATER: water that is not harmful and can be drunk

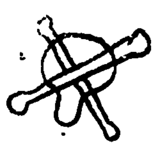
18. PERSISTENT CHEMICALS: chemicals that <u>don't</u> <u>break</u> <u>down</u> for many years

19. RUN-OFF: anything washed off the land by heavy rains, etc.

20. SEDIMENT: soil that settles to the bottom of a body of water

21. STORMSEWER: a system of pipes and ditches that collect street water after a rain; also collects all the trash and dirt; in some cities these empty directly into the creeks and rivers

22. SLUDGE: the solid matter left after sewage is treated



23. SEWAGE: the waste matter carried off in sewers

24. TOXIC: poisonous

25. THERMAL POLLUTION: overheating of a body of water--often by industries dumping water from their cooling systems into the water

26. TURBID: cloudy

STENCIL

SUPPLEMENT #12

Quiz on Key Words

Terms

Algae	Persistent Chemicals
Algal Bloom	pH
Biodegradable	Pollutant
Coliform Bacteria	Pollution
Effluent	Potable water
Erosion	Run-off
Eutrophication	Sediment
Malodorous	Sewage
Municipal Sewer	Sludge
Nitrates, phosphates	Stormsewer
Noxious	Thermal Pollution
Organic	Toxic
Pathogenic bacteria	Turbid

Write the correct term beside its definition. Use the terms given above.

Term	Definition
1. ________	bacteria present in sewage
2. ________	the solid matter left after sewage is treated (can be used as fertilizer)
3. ________	overgrowth of algae in a body of water
4. ________	the liquid that's left after sewage is treated
5. ________	the waste matter carried off in sewers
6. ________	city pipelines that carry sewage to the treatment plant
7. ________	system of pipes and ditches that collect street water after a rain; also collects all the trash and dirt; in Washington these empty directly into the creeks and Pamlico
8. ________	contamination that upsets the natural balance
9. ________	thing that contaminates disease-causing bacteria
10. ________	a term used to determine how much acid or base a liquid has; a pH between 6.5 and 8 is a suitable environment for most organisms; below 6.5 is too acid; above 8 is too basic

Supplement #12 (Cont.)

	Term	Definition
12.	______________	removal of soil and its pollution by rainwater--often ends up in the water
13.	______________	CHEMICALS THAT DON'T BREAK DOWN FOR MANY YEARS
14.	______________	harmful, irritating, annoying
15.	______________	poisonous
16.	______________	has a foul, bad odor
17.	______________	two chemicals present in sewage, fertilizers, and detergents that feed algae and cause them to overpopulate
18.	______________	tiny plants that live in the water
19.	______________	anything washed off the land by heavy rains
20.	______________	substances (like food particles) that can be decayed (decomposed) by organisms feeding off it
21.	______________	overheating of a body of water--often by industries dumping water from their cooling systems into the water
22.	______________	cloudy
23.	______________	soil that settles to the bottom of a body of water
24.	______________	can be decomposed by organisms
25.	______________	not harmful, can be drunk

Teacher: cover this key if stencil is to be duplicated.

Key

1. Coliform bacteria
2. Sludge
3. Algal Bloom (Eutrophication)
4. Effluent
5. Sewage
6. Municipal Sewer
7. Stormsewer
8. Pollution
9. Pollutant
10. Pathogenic Bacteria
11. pH
12. Run-Off (erosion)
13. Persistent Chemicals
14. Noxious
15. Toxic
16. Malodorous
17. Nitrates, Phosphates
18. Algae
19. Run-off (erosion)
20. Biodegradable (organic)
21. Thermal Pollution
22. Turbid
23. Sediment
24. Biodegradable (organic)
25. Potable Water

SUPPLEMENT #13

The River Must Live

Rivers have long been used both as a source of fresh water and a means of sewage disposal; pollution only became a serious problem with the growth of industry and large cities. This growth brought simultaneously an increased dependence on lakes and rivers for fresh water supplies and a vast increase in the volume of water-borne waste. The film shows what happens when a river is overloaded with more waste than it can absorb, and the consequences to those who depend on it.

Pollution can only be prevented if the way a river absorbs waste is understood. The film shows in microscopic detail the organisms which preserve the balance of life in a healthy river. The natural mechanism of self-purification is slow; it needs time and space. Too much waste in too short a space overloads the river, killing the microorganisms which keep it clean. The river then becomes permanently polluted.

To prevent this happening, much more wide-spread treatment of industrial and urban waste is necessary. This will be expensive but the benefits will greatly outweigh the cost.

SUPPLEMENT #14

Game Problems and Clues

MAIN PROBLEM	CLUES
too hot to live in	You'll know if this problem exists when you measure the temperature.
	The source of this problem is from atomic power plants generating heat (very high temperatures) in their water supplies.
	This problem is caused by industrial cooling systems (and other processes) releasing their water directly into the river.
water animals can not get enough oxygen to breathe	The reasons for this problem are too much phosphate and nitrate in the water resulting in algal blooms, too much organic (biodegradable) wastes in the water (like detergents, garbage, raw sewage).
	This problem is caused by the presence of too many nutrients (like phosphates and nitrates) which cause the algae to grow "like mad" (called an algal bloom). Then when the algae die the bacteria have a feast on them.
	You'll know if this problem exists when you find out the amount of phosphates and nitrates present.
	To find out if this is a problem, you can measure the amount of dissolved oxygen in the water.
	This problem is caused by the presence of too many bacteria in the water.

Supplement #14 (Cont.)

disease	The main source of this problem is sewage from sick people getting into the water.
	The State Department of Public Health should be notified if you suspect this problem exists.
	You'll know if this problem might exist when you count the number of fecal coliform bacteria present.
	Fish and shellfish beds are closed to fishing if untreated sewage is being dumped into the body of water.
	Specific examples of this problem are: typhoid fever, polio, cholera, cold germs, dysentery (diarrhea), hepatitis, flu.
	The source of this problem is mainly farm run-off, treated and untreated sewage.
plants don't get enough light; bottom dwellers get buried; fish can't see, and gills get clogged	This problem is caused by overcutting of trees, careless farming (soil erosion), channelization and urbanization (building of housing developments).
	This problem is caused by soil erosion
	You'll know if this problem exists when you measure the turbidity.
	This problem is found near eroded farmlands, in dammed reservoirs, and near land construction sites

Supplement #14 (Cont.)

too acidic to live in	This problem is caused by wastes and run-off from mines, untreated industrial wastes, and even air pollutants that mix in the rain water (carbon dioxide will yield carbonic acid, sulfur dioxide will yield sulfuric acid, nitrogen oxide will yield nitric acid).
	You'll know this problem exists when you measure the pH of the water and it's less than 6.5.
	This problem is caused by air pollutants and wastes from mines and industries.
poisoning	The source of this problem is mainly farm run-off (and erosion) and industrial wastes.
	Oysters and other shellfish beds are closed to fishing because the shellfish have eaten the causes of this problem.
	Specific examples of this danger are: pesticides (like DDT), heavy metals (like mercury and lead), and 'weird' chemicals made by man.
	This happens even if the pollutants are present in very small amounts because the plants and animals eat the pollutants (via their food chain) and concentrate them in their bodies.
	It is difficult to know if this problem exists until organisms begin to die. Then it is too late.
	The chemical tests to detect poisons are very difficult to perform and very expensive. For some poisons, there is no detection test known.

SUPPLEMENT #15

Teacher Information Chart for the Game

To the Teacher

The information given is possible responses that the students might give.

Problem	How it arises	Test for	Solution to or how to eliminate
too hot to live in	wastes from atomic power plants water from industrial cooling system released into water	measure temperature	require companies to reduce water temperatures before it returns to the main water source
water animals can't get enough oxygen to breathe	too much phosphate and nitrates in water too much organic (biodegradable) wastes like detergents in water too many bacteria present algal blooms	measure the amount of dissolved oxygen	reduce the amounts of nutrients and biodegradable products entering water construct sewage treatment plants which will remove nitrates and phosphates

Supplement #15 (Cont.)

diseases (polio, cholera, typhoid fever, colds, flu hepatitis)	farm run-off entering water treated and untreated sewage entering water	count the number of fecal coliform bacteria State Health Department does extensive tests	better treatment of human sewage (elimination of septic tanks) treatment of farm run-off
plants don't get enough light; fish can't see, gills get clogged; bottom dwellers get buried	soil erosion land construction sites dammed reservoirs industrial wastes entering water	measure turbidity	practice soil conservation such as contour plowing, cover crops, etc. practice "ecological" construction require industries to treat their wastes
too acidic to live in	wastes from mines and industries enter the water air pollutants fall with rain	measure the pH of water (acidic if less than 6.5)	require treatment of industrial wastes require industries to have air filters to remove CO_2, SO_2, NO_2

UNIT II: IS WATER A RENEWABLE RESOURCE?

Activity Plans

How Are Pollutants Removed From Water?

TIME: 2½ periods

INTRODUCTION:

Organized into nine stations are water purification methods that tend to purify water naturally. The methods used are as follows: individual columns of sand, rock, clay; flasks containing soil bacteria in water; settling; anaerobic bacterial digestion; freezing (crystallization); absorption by charcoal, and a distillation apparatus.

The students are to be assigned to one of the stations and instructed to "man" and control their station. Equal portions of the students' polluted "river" is to be subjected to purification by the students. Sufficient time should be allowed for student observation of all the stations and research on the specific purification methods being observed so that the final evaluation results will be meaningful.

MATERIALS

Reference books: Refer to supplement #9, Bibliography - Pollution: Scientific

Lab equipment: Refer to supplement #16, Stations for Water Purification Lab and Diagram

Student Directions: Refer to supplement #17

DESCRIPTION OF PURIFICATION STATIONS

STATIONS 1, 2, and 3: FILTRATION

rock, sand, and clay columns-use glass or plastic cylinders, each filled with one type of soil; for any one type of soil columns of various heights could be built (e.g. sand to a depth of 3 inches in one column and 3 feet in a second column)

STATION 4: ABSORPTION

charcoal - charcoal is added to the polluted water, heated, and filtered through filter paper

STATION 5: DISTILLATION

STATION 6: AEROBIC DECOMPOSITION BY MICROORGANISMS

flask of soil bacteria inoculated into an aliquot of the polluted water, and aerated with an aquarium pump; suggested source of bacteria: ESCHERICHIA COLI, FLAVOBACTERIUM, AEROBACTER, BACILLUS, CLOSTRIDIUM, PSUEDOMONAS, PROTEUS; have available a warm dark place, approximately 100 degrees F. to incubate flask of bacteria and speed up decomposition; have available a microscope with a stained slide showing bacteria focused at 100 x (oil immersion, is possible); the hospital can also supply the stained slide.

STATION 7: ANAEROBIC DECOMPOSITION BY MICROORGANISMS

an aliquot of polluted water plus some of the strained solid matter is stored in a tightly capped jar in a warm, dark place for at least a week.

STATION 8: FREEZING, SETTLING, AND CONTROL

SUGGESTED SCHEDULE:

Day 1, Before class set the "river", seven beakers, and a strainer (a large tea strainer works nicely) on a table or lab cart located in the front of the room. Also set up the eight stations (refer to supplement #16) on separate tables and tape student instructions to the stations (supplement #17).

At the beginning of class assign groups of students to each one of the stations. Briefly explain the lab to the students. Point out that reference materials are available for each station. Also explain that the purpose of the lab is to attempt to purify the polluted river by the methods given, and determine which method is most effective. Ask the students to consider which methods occur naturally, and which are artificial.

Instruct one student to mix and strain (if necessary) the polluted "river" filling eight containers with equal amounts of the river. This liquid is then put into the purification system at each station. After the students have their purification system set up and functioning they should then spend the remainder of time using the available reference materials and observing the other stations. Before the end of the period the distillation should be stopped, the flask incubated, the container from station seven put in a place where it will not be touched, and the container from station eight put in the freezing unit of the refrigerator. Unless otherwise specified, all water samples should be refrigerated.

Day 2: Arrange the labelled effluents on a front table. The students should determine which method was most effective based on their observations of the collected effluents from each station and any data collected during the purification process.

To lead into a discussion of purification methods the following chart could be utilized:

Natural method of purification	Occurrence in nature	Use in water treatment plants	Comments (Effectiveness of)
Settling			
Filtration			
Bacterial Decomposition			
aerobic			
anaerobic			
Distillation			
Charcoal Absorption			
Freezing			

The following ideas could also be pursued during the discussion: explanation of how each method works, what pollutants are removed most effectively by each method; effectiveness of combining several methods (this does happen in nature and most water treatment plants combine methods); effects of the time and concentration factors on the functioning efficiency of the purification methods; the effect the lack of any chemical analysis on effluent has in determing quality of the sample.

Key terms to bring out are as follows: suspended and dissolved solids, biodegradable, sludge, effluent, sewage, organic waste, and concentration. Other key words for the students to become familiar with are given in supplement #12.

After completion of the lab and discussion, a good follow-up activity is a trip to the city water and sewage treatment plant and to a local industry's water treatment facilities (if such exist), so the students can observe how surface and waste water is treated both for personal and industrial use. Refer to supplement #18, Questions for Water Treatment Plant, in the post-activity plans.

NOTES:

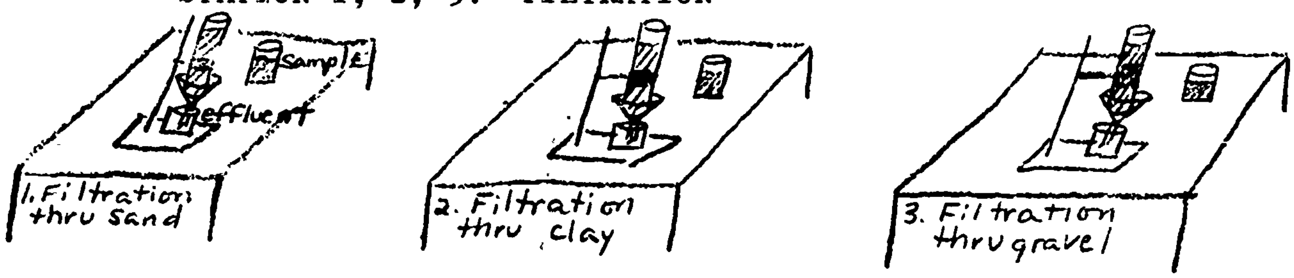
This is a fascinating lab filled with an overabundance of learning experiences for both the students and the teacher! For example, we learned:

1. The polluted river if left to stand at room temperature undergoes bacterial degredation. One teacher left a dark blue "river" one afternoon to see a colorless "river" the next morning! Needless to say, she added more methylene blue to the jar before the students arrived!
2. The distilled effluent was clear and appeared unpolluted. However, it "reeked" of a very unpleasant organic odor. The students were shocked to learn that pollutants with a lower boiling point than water would not be removed during the water cycle!
3. The sample containing aerobic bacteria in one class discolorized and in other two classes did not. The bacterial innocula were identical so we concluded that two rivers contained pollutants toxic even to the bacteria!

SUPPLEMENT #16

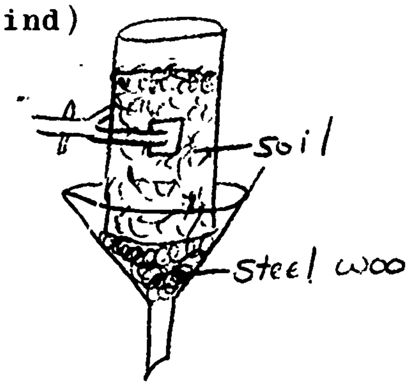
Stations for Water Purification Lab and Diagram

STATION 1, 2, 3: FILTRATION

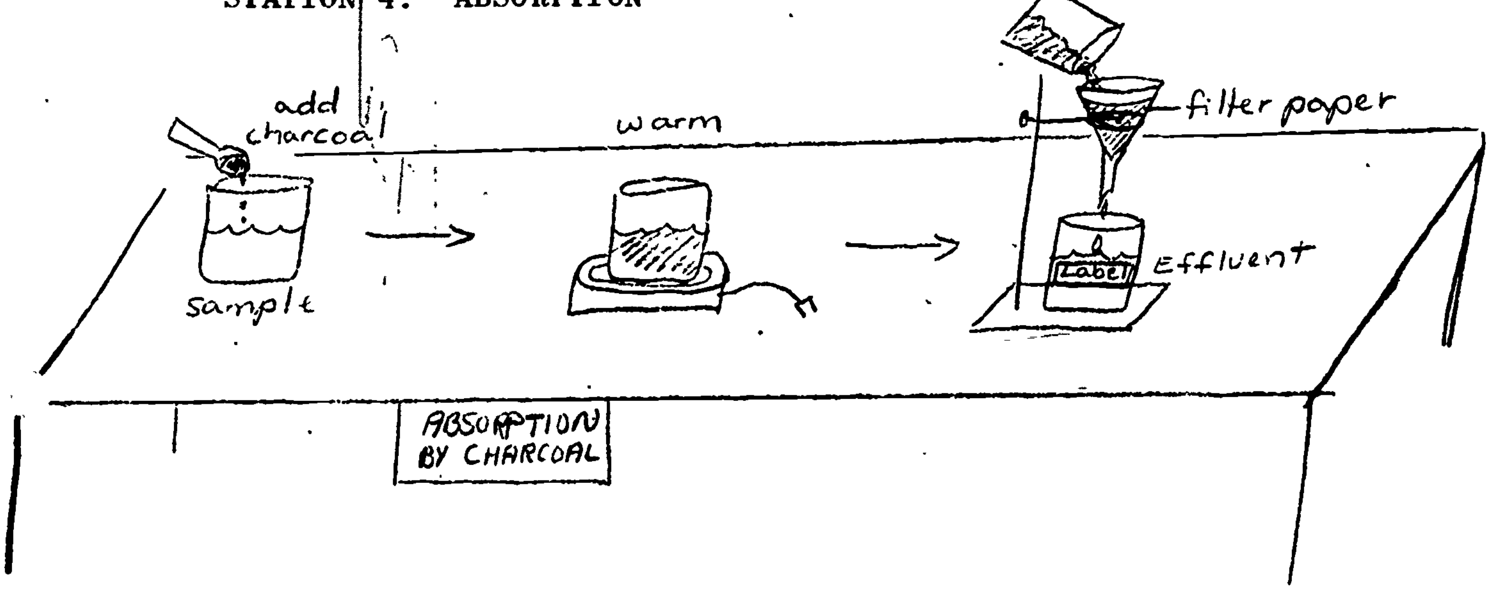


Equipment:

3 glass columns (approximately 8" [length] x 2" [diameter]) (or any size you can find)
3 funnels
6 beakers (includes those needed for the sample) 250 ml.
3 poles or ringstand and clamps
aluminum foil (to put over collected effluent)
tape
student directions and references
clay, sand, gravel (aquarium type works fine)
steel wool (lay this in the funnel to hold the soil)



STATION 4: ABSORPTION

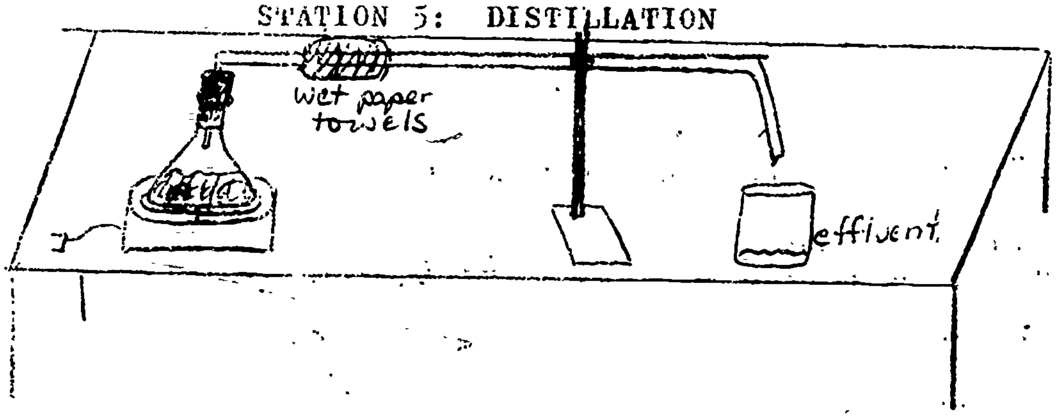


Supplement #16 (Cont.)

Equipment:

2 beakers (includes the one needed for the sample) 250 ml
aluminum foil
1 hot plate
1 spoon
small amount of fine charcoal (1 tablespoon per 200 ml of sample)
filter paper
funnel
gloves, tongs, or asbestos pad
tape
student directions and references

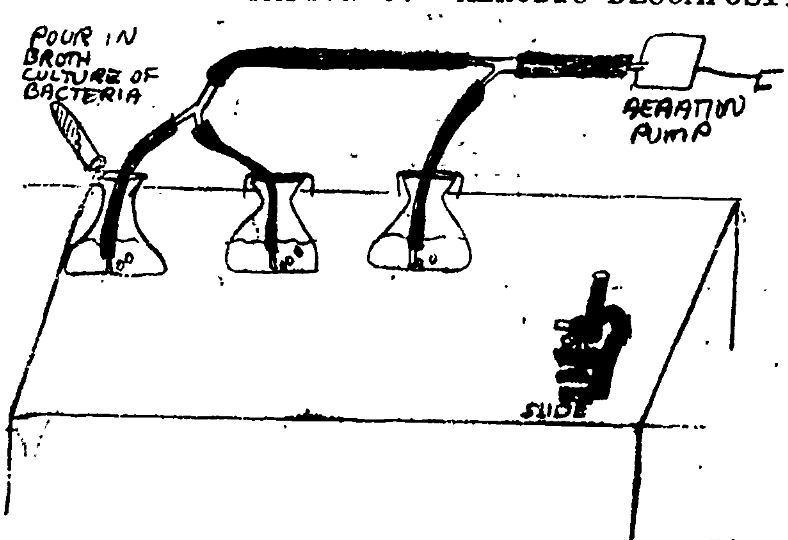
STATION 5: DISTILLATION



Equipment:

1 Erlenmeyer flask
hot plate or bunsen burner
paper towels
1 one-hole rubber stopper
glass tubing
labelling tape
2 beakers (includes beaker for the sample) 250 ml
aluminum foil

STATION 6: AEROBIC DECOMPOSITION BY MICROORGANISMS



If you have a limited number of aeration pumps, it is possible to hook-up several flasks to one pump using "y" tubes as shown in the following diagram:

Supplement #16 (Cont.)

Equipment:
- 1 Erlenmeyer flask <u>per class</u>
- 1 aeration pump
- rubber tubing
- cardboard box
- "y" tubes
- cultures of <u>Escherichia coli</u> (obtain from hospital or university); request broth culture for convenience in inoculating
- 1 beaker (for the sample) 250 ml.
- student directions and references
- 1 microscope, slide, immersion oil
- labelling tape

STATION 7: ANAEROBIC DECOMPOSITION BY MICROORGANISMS

Equipment:
- 1 jar with a tight-fitting lid per class
- aluminum foil to wrap around jar
- labelling tape
- student directions and references

STATION 8: CONTROL, FREEZING, AND SETTLING

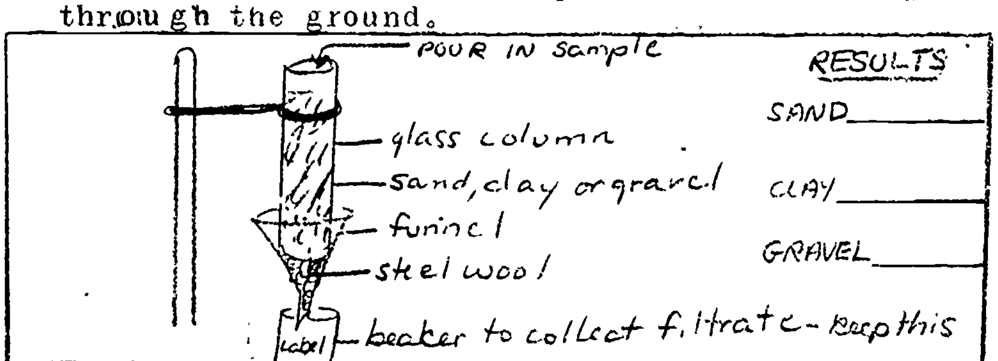
Equipment:
- 3 beakers per class (250 ml.)
- 2 graduated cylinders
- aluminum foil
- tape
- student directions and references

SUPPLEMENT #17

Student Directions for Purification Lab

STATION 1, 2, 3: FILTRATION

This is how water is purified (filter.. g or percolating) through the ground.



Procedure:
1. Pour exactly and very slowly 200 m.. (milliliters) of polluted water into the top of the column. Be sure the beaker is directly under the stem of the funnel. Note and record the time you begin to pour the liquid.
2. Allow the water to completely filter (percolate) through the sand, clay or gravel.
3. Note the time when no more water drips into the beaker.
4. Label the beaker (use tape).
   period_____filtrate - sand, filtering time______min.
5. Cover the beaker with aluminum foil and place it in the refrigerator.

Everyone: copy the portion above that's boxed-in (☐). Leave three lines for the results and label each line:

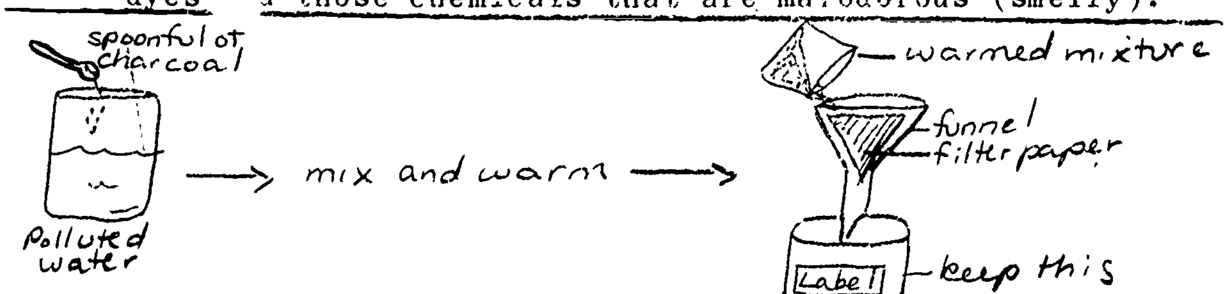
sand ____________________

clay ____________________

gravel ____________________

STATION 4: ABSORPTION AND FILTRATION BY CHARCOAL (CHARCOAL AS A PURIFYING AGENT)

Charcoal (carbon) absorbs many chemicals, especially dyes d those chemicals that are malodorous (smelly).



(psst.... now what do you do with the charcoal??)

RESULTS: ____________________

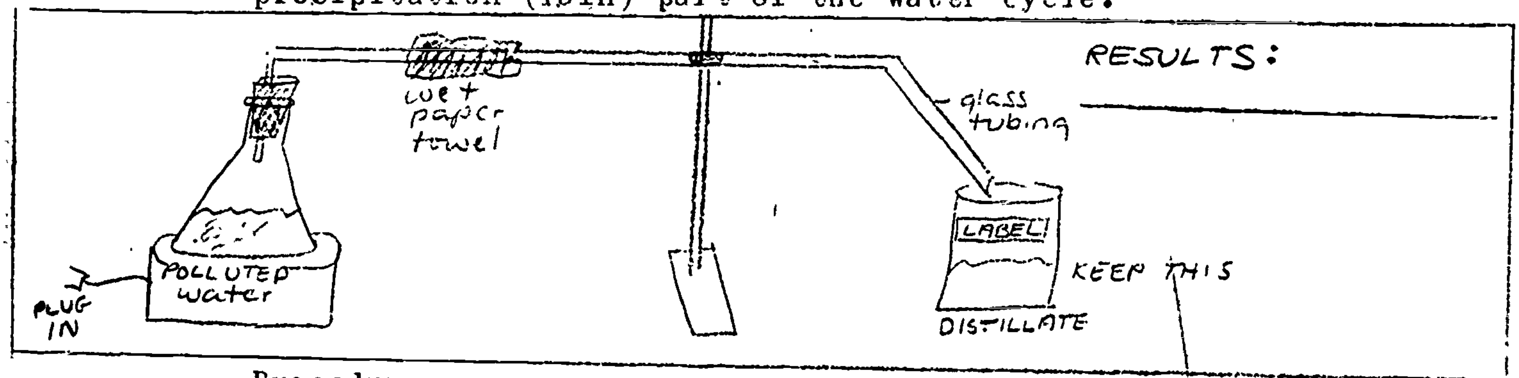
Supplement #17 (Cont.)

Procedure:
1. Pour exactly 200 ml. (milliliters) polluted water into a beaker. Use a graduated cylinder to measure the liquid.
2. Add one tablespoon (level) of charcoal.
3. Mix and warm on a hot plate until the mixture <u>just begins</u> to boil.
4. Let the mixture cool until you can handle it.
5. Filter the mixture (charcoal + polluted water) through a funnel which should be supported.
6. Label the beaker (use tape):
   period __________ charcoal absorption
7. Cover the beaker with aluminum foil and place it in the refrigerator.

<u>Everyone</u>: Copy the portion above that's boxed in ( ). Leave one line for the results.

STATION 5: DISTILLATION

This is a speed version of the evaporation - condensation - precipitation (rain) part of the water cycle.



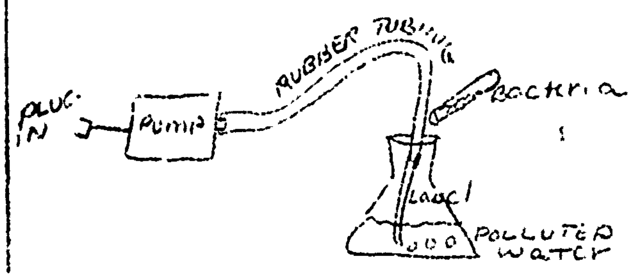
Procedure:
1. Pour exactly 200 ml. (milliliters) of polluted water into the flask. Use a graduated  cylinder to measure the liquid.
2. Set-up the above experiment. Heat the polluted water in the flask until it begins to boil.
3. Continue heating until a distillate collects in the beaker.
4. Label the beaker (use tape):
   period ______ distillate, distilling time ________ min.
5. Cover the beaker with aluminum foil and place in the refrigerator.

<u>Everyone</u>: Copy the portion above that's boxed-in ( ). Leave one line for the results.

Supplement #17 (cont.)

STATION 6 AEROBIC DECOMPOSITION BY MICROORGANISMS
(digestion by bacteria that use oxygen)

This is how the biodegradable substances in polluted water are removed. Bacteria are gobbling up (digesting) the biodegradable things.



RESULTS:
after 24 hr. ____________
after 72 hr ____________

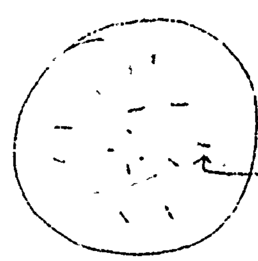
Air is bubbled in so the bacteria get enough oxygen to "breathe". Without oxygen they cannot completely digest and decompose the wastes. This process happens in swiftly moving streams.

Procedure.
1. Carefully pour the culture of <u>Escherichia</u> (E - sher - i - shi - a) <u>coli</u> into the erlenmeyer flask. DO NOT GET ANY ON YOUR HANDS.
2. Pour exactly 200 ml. (milliliters) polluted water into the Erlenmeyer flask. Swirl to mix.
3. Connect the aerator to the flask using rubber tubing. Incubate the flask in a warm dark place.
4. Label the flask (use tape):
   period ______________ bacterial decomposition (aerobic)

<u>Everyone</u>: Copy the portion above that's boxed-in ($\square$). Leave one line for the results.

To the teacher
The following directions should be placed at STATION 6 also:

Look in the microscope to see the stained bacteria. Bacteria are hard to see unless they are stained (most are colorless). PLEASE, only focus with the fine adjustment knob (it's labelled).



the bacteria are the skinny, dark-colored rods

Supplement #17 (Cont.)

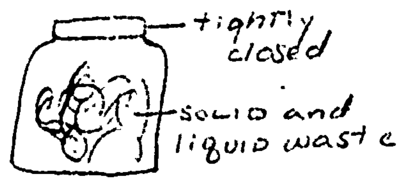
DO NOT MOVE ANYTHING BUT THE LABELLED KNOB

DO NOT SHAKE OR MOVE THE TABLE

Everyone. Copy the portion abov . ed-in ( ).

STATION 7: ANAEROBIC DECOMPOSIT . ROORGANISMS
(digestion by bacte t do not use oxygen)

This is how the biodegradable subst nces in polluted water are removed. Bacteria are ing up (digesting) the biodegradable things.



RE

The lid must be tight because we want no oxygen to get in the jar. These bacteria do not use oxygen to live. They also do not digest the wastes completely. They excrete very malodorous (smelly) wastes themselves as they eat. This process happens in septic tanks and in stagnant (non-moving) or sluggish (slow-moving) bodies of water. You'll know these by the odor.

Proced e:

1. Add the solid wastes that have been screened from the polluted water to the jar. Fill the jar as full as possible. Include some of the liquid also.
2. Screw the cap on tightly.
3. Wrap aluminum foil around the glass (remember these bacteria like dark places).
4. Label the jar's lid (use tape):
   period__________ bacterial decomposition (anerobic)

Everyone: Copy the portion above that's boxed-in (□). Leave one line for the results.

STATION 8: CONTROL, FREEZING, AND SETTLING

CONTROL
We are performing many experiments to try to purify the polluted water. How can we tell how good our methods are unless we can compare our results to the original polluted water? Will you remember exactly how the polluted water looks? Just to be sure we'll save some of the polluted water by storing it in the refrigerator to prevent bacteria from growing in it too fast.

Supplement #17 (Cont.)

Procedure:
1. Pour exactly 20` ml. (milliliters) of polluted water into a clean beaker. Use a graduated cylinder  to measure the liquid.
2. Label the beaker (use tape):
   period__________control
3. Cover the beaker with aluminum foil and set it in the refrigerator.

Everyone: Copy the portion above that's boxed-in (☐). Leave one line for the results.

To the teacher
The following directions should be placed at STATION 8 also:

FREEZING (CRYSTALLIZATION)
When water is frozen most pollutants (impurities) are forced out of the water. Since the water molecules bond together, the impurities will be found in the center of a block of ice. The ice can be melted and the center part thrown away. (Well, anyway, let's try it . . .ok?) RESULTS:______________________

Procedure:
1. Pour exactly 200 ml. (milliliters) of polluted water into a beaker. Use a graduated cylinder  to measure.
2. Label the beaker (use tape):
   period__________freezing
3. Place the beaker in the freezing compartment of the refrigerator.
4. The next day remove the beaker. Melt most of the ice. Remove and throw away most of the center.

Everyone: Copy the portion above that's boxed-in (☐). Leave one line for the results.

SETTLING
In a still body of water, many particles that do not dissolve will eventually settle to the bottom. Of course, this doesn't really remove the pollutants, it just changes their location!

Procedure:
1. Pour exactly 200 milliliters of polluted water into a beaker.
2. Label the beaker (use tape):
   period______________settling
3. Place the beaker way back in the refrigerator where it won't be disturbed.

Everyone: copy the portion above that's boxed-in (☐). Leave one line for the results.

UNIT II: IS WATER A RENEWABLE RESOURCE?

Post-Activity Plans

How Our City Treats Its Water

TIME: 3 periods

SUGGESTED ACTIVITIES

Day 1. This post-activity should finally answer the question which titles Unit II.

In preparation for the field study of the city's water and sewage treatment facilities, review supplement #18 with the students.

Day 2. Trip to the city's water and sewage treatment plant and to a local industry's water treatment facilities

Day 3. Review answers to the questions with the students. Discuss the efficiency of the local system's water and sewage treatment plant. A question to stimulate discussion might be as follows: Is Water a renewable resource?. Other points to discuss are (1) water is purified of most wastes if given time, and if the concentration of wastes is not too great; (2) today there are so many people with such great demands on the water supply that nature's processes must be speeded up by using a system of water treatment plants; (3) many communities today do not have treatment plants or ones that do the most efficient job; (4) wastes such as pesticides, heavy metals, radioactive wastes are not removed by many treatment plants; (5) pesticides and other such waste concentrate in the food chain causing mutations and death.

STENCIL

SUPPLEMENT #18

Municipal Water Treatment: City of ______________

Fill in the answers to the following questions:

I. Water Purification for Drinking:

1. Where does our drinking water come from?

2. Is there as much water available as there used to be? Yes _____ No _____

3. Is the water supply as pure as it used to be?
Yes _____ No _____
Facts:

4. Who receives treated water from this plant?

5. What is the cost of cleaning the water?

II. Sewage Treatment:

1 How does the sewage get to the plant?

2. How are the large items of trash removed?

3. How are the biodegradable materials (organic wastes) removed?

4. What is done with the wastes removed from the water?

5. How could our sewage treatment be improved?

Is it going to be improved? Yes _____ No _____
Facts:

6. How much does it cost to treat the sewage?

7. How do large rainfalls affect our sewage treatment plants?

8. What kind of sewage treatment does our city have:

Primary _______ Tertiary _______

Secondary _______ None _______

9. What does not get removed by our treatment plant? (List)

WATER POLLUTION EXAM

I. Choose the best answer.

1. Which play a part in the natural water cycle:
a. evaporation; b. condensation; c. animals;
d. plants; e. all four; f. all except (c)

2. People who live in our city obtain their drinking water from:
a. b.
c. d.

3. How much of the earth is covered with water?
a. 1/4; b. 1/2; c. 3/4; d. 1/3

4. Rain water sinks into the ground until it reaches a certain level called the a. seepage line;
b. water table; c. artesian well; d. water line

5. Into what body of water is treated sewage from our city discharged:
a. b.
c. d.

6. Rain and snow that don't seep into the ground:
a. evaporate; b. are absorbed by plants;
c. are used by animals; d. fill lakes, rivers, and other bodies of water; f. only a, b, and c;
g. all 4 (a, b, c, d)

7. Which statement best describes water:
a. water is a renewable resource; b. water is a renewable resource only under normal natural conditions, but not when man pollutes it so heavily and with so many kinds of chemicals, c. during the water cycle, water is purified; d. new water molecules are always being formed so that we'll never run out of fresh water

8. The really bad thing about poisons that pollute water is that: a. even in very small amounts, they are dangerous, b. many have no odor, no color, no taste so you don't know you're eating them;
c. there are so many different kinds that most aren't even tested for and no test is known for some; d. the poisons stay in your body and accumulate causing damage many years from now; e. all the above are really bad things

9. Which of the following does not play a role in the natural purification of water: a. bacteria; b. evaporation; c. filtration through soil; d. aluminum sulfate and alum coagulation; e. freezing

10. Which of these contributes to water pollution: a. land abuses; b. air pollution; c. rain; d. septic tanks; e. all above; f. all except (c)

11. Which of the following methods removes all impurities (pollutants) from water; a. filtration through soil: b. charcoal absorption; c. freezing; d. distillation; e. aerobic bacteria; f. anaerobic bacteria; g. none of the above removes all pollutants

12. A swiftly moving stream purifies water by all the following except one. Which method would not be at work? a. aerobic bacteria; b. filtration; c. settling out of large particles; d. anaerobic bacteria

II. Write the proper terms beside the definition:

ALGAE, PATHOGENIC, BIODEGRADABLE, PHOSPHATES, POTABLE, TOXIC, EFFLUENT TURBID, NITRATES, MALODOROUS

13. The liquid left after sewage is treated

14. Poisonous

15. Can be decomposed by organisms

16. Two chemicals present in sewage and fertilizers that feed algae

17. Disease-causing bacteria

18. Water that can be drunk

19. Tiny plants living in water (that most people call "scum")

III. Choose the best answer

20. The waste removed from the water at the sewage treatment plant (the dried sludge) is: a. buried; b. not used as a fertilizer, but could be; c. dumped into the river along with the effluent; d. only a and b above; e. all three-a, b, c

21. Which of the following processes plays the main role in removing wastes from the sewage at the city plant: a. filters; b. chemicals; c. bacteria; d. settling tanks

22. Our city's sewage receives: a. primary treatment; b. secondary treatment; c. tertiary treatment; d. no treatment

IV. Please place these events (23-28) in the proper order in which they occur in a body of water. Number them from 1 to 6.

_______ 23. bacteria over-populate

_______ 24. algae overpopulate due to over-abundance of nutrients

_______ 25. huge masses of algae die

_______ 26. large amounts of nitrates and phosphates enter the water from farm run-off; sewage and effluent from sewage treatment plants

_______ 27. the oxygen is used up

_______ 28. the fish die

29. the term which best describes the above series of events is: a. algal bloom, b. eutrophication; c. suffocation; d. poisoning

V. Arrange the following events in the proper order, numbering them from 1 to 11.

30. The birds become extinct

31. The ditch empties into the river

32. The plankton eat the DDT and die; the fish eat the plankton

33. The birds eat the fish

34. The farmer sprays DDT on his cotton

35. The birds lay eggs

36. The soil and DDT wash into the ditch

37. The river empties into the ocean

38. The eggs don't ever hatch

39. The rain rinses the DDT into the ground

40. It rains

VI. Choose the best answer.

41. Which of the following is not true about DDT: a. it evaporates with water; b. it lasts for many years without breaking down; c. it is biodegradable; d. it kills the oxygen-producing plankton the water; e. it is poisonous to man

42. Which of the following types of pollutants is not removed from water by distillation: a. most dyes; b. sand or other solid particles; c. salt dissolved in the water; d. chemicals that evaporate easily

43. To find out if there is a possibility of pathogenic bacteria being present in a water supply, which test is run: a. turbidity test; b. coliform test; c. phosphate test; d. none of these

44. To find out if there is a lot of biodegradable garbage in the water that is being decayed, which test is run: a. dissolved oxygen; b. coliform test; c. turbidity; d. pH

45. To find out if the water is being polluted by acid waste from factories and mines, which test is run: a. pH; b. turbidity; c. phosphates; d. nitrate

46. Which test will tell you if untreated sewage is getting into the water: a. coliform test; b. pH; c. turbidity; d. phosphate

47. A body of water that shows a large amount of phosphate and nitrate: a. is in danger of eutrophication; b. may receive large number of treated or untreated sewage; c. may receive a lot of farm run-off; d. all of the above

48. If a body of water is very turbid and its bottom is silty and soft: a. it's receiving a lot of land pollution; b. the surrounding land is eroding; c. the fish may not be able to survive; d. all the above

49. If you find a lot of coliform bacteria in the water:
a. it means the water is safe to drink;
b. it means no fish or shellfish that live in the water can be eaten;
c. it means there is a lot of farm run-off in that area;
d. all of the above

50. Which statement is NOT true?
a. water chemistry test must be performed very accurately;
b. when you do water chemistry tests you must rinse all equipment with distilled water;
c. in the coliform test, the broth, pipettes, and most other equipment must be sterilized;
d. if you don't have time to run the water tests in one day, you can keep some of the water sample and run some of the tests on another day

51. Which of the following quotes is made by an owl:
a. "Pollution makes the world go brown"
b. "Give a hoot, don't pollute"
c. "If you're not a part of the solution, you're part of the pollution"
d. "Wildlife is trying to tell us something; seen any wildlife lately?"

STENCIL

SUPPLEMENT #19

Answer Sheet and Key fo Exam

1.	e.	2.	
3.	c.	4.	b.
5.		6.	g.
7.	b.	8.	e.
9.	d.	10.	a.
11.	g.	12.	d.
13.	effluent	14.	toxic
15.	biodegradable	16.	nitrates & phosphates
17.	pathogenic	18.	potable
19.	algae	20.	d.
21.	c.	22.	
23.	4.	24.	2.
25.	3.	26.	1.
27.	5.	28.	6.
29.	b.	30.	11.
31.	5.	32.	7.
33.	8.	34.	1.
35.	9.	36.	4.
37.	6.	38.	10.
39.	3.	40.	2.
41.	c.	42.	d.
43.	b.	44.	a.
45.	a.	46.	a.
47.	d.	48.	c.
49.	b.	50.	d.
51.	b.		

UNIT III PLAN

UNIT III TITLE: SCIENTIFIC ANALYSIS OF LOCAL WATER QUALITY

TIME: Based on a twelve week schedule you can spend anywhere from $9\frac{1}{2}$ to 14 periods on this unit depending on how much emphasis you wish to give it and the number of activities you include.

PURPOSE OR OBJECTIVE

For students to become knowledgeable of how waterways are classified and of the classification of local waterways.

By performing certain analytical tests, students will gain experience in performing scientific tests; will acquire skills and accuracy in water quality analysis; will have the knowledge and experience necessary to evaluate the quality of local waterways; and will be able to initiate the formation of a plan for solving a local water quality problem.

ABSTRACT

Students first become acquainted with the method for classifying surface waters. Then the classifications of local waterways are noted. To increase the students' knowledge, authorities in water quality analysis are visited or invited into the classroom as speakers. Following this, water analysis of a local major waterway is undertaken. Based upon the advice of authorities and the results of the students' (or authorities) water studies, a local problem is identified and a plan is initiated to attempt to solve this problem.

UNIT III SCHEDULE

To the teacher

Given are several suggested activities for which there are different approaches. All the activities do not have to be done. How much time is spent on this unit directly relates to the amount of emphasis you wish to place on Unit IV. Perhaps the best suggestion is to prepare a tentative outline and subject it to change once you and your students are engaged in the activities and you are more knowledgeable of their response to the materials.

PART A	CHEMICAL ANALYSIS Introduction Lecture or Tour Practice Stations Performing Chemical Tests Discussion of Results	approximately 7 periods
PART B	BACTERIAL ANALYSIS Introduction Lecture or Teacher Presentation Practice Stations Performing Bacterial Tests Analyzing Results Discussion of Results	approximately 7 periods
PART C	EVALUATION AND SELECTION OF A PROJECT	approximately 2 periods

UNIT III
Equipment and Supplies

I. Chemical Analysis of Water

Test kits are available which contain all the supplies needed, however the kits are costly. Supplements 22 and 24 are written for use with kits, but if your school cannot afford to purchase the listed materials, contact your municipal water plant and the nearest office for the Board of Water and Air Resources, Department of Natural and Economic Resources (in North Carolina) for assistance and possibly demonstrations. Local water softener companies may also be of some help

Delta Scientific Model 50 Portable Laboratory includes built-in test meter, color filters, lab ware, reagents to perform 21 tests for: acidity, alkalinity, bromine, calcium hardness, carbon dioxide, chlorides, chlorine, chromate, copper, hydrogen sulfide, iron, manganese, nitrate nitrogen, nitrite nitrogen, phosphate and polyphosphate, pH, turbidity, sulfate, sulfite (refills available).

Cost: $248 (!)

Address: Delta Scientific Corporation
120 East Hoffman Avenue
Lindenhurst, N. Y. 11757

Phone: (516) 884-4422

Model EDO Code 7414 Dissolved Oxygen
Uses modified Winkler method; makes 25 tests; is a field kit.

Cost: $19.95

Address: Educational Products Division
LaMotte Chemical Products Company
Chestertown, Maryland 21620

Phone: (301) 778-3100

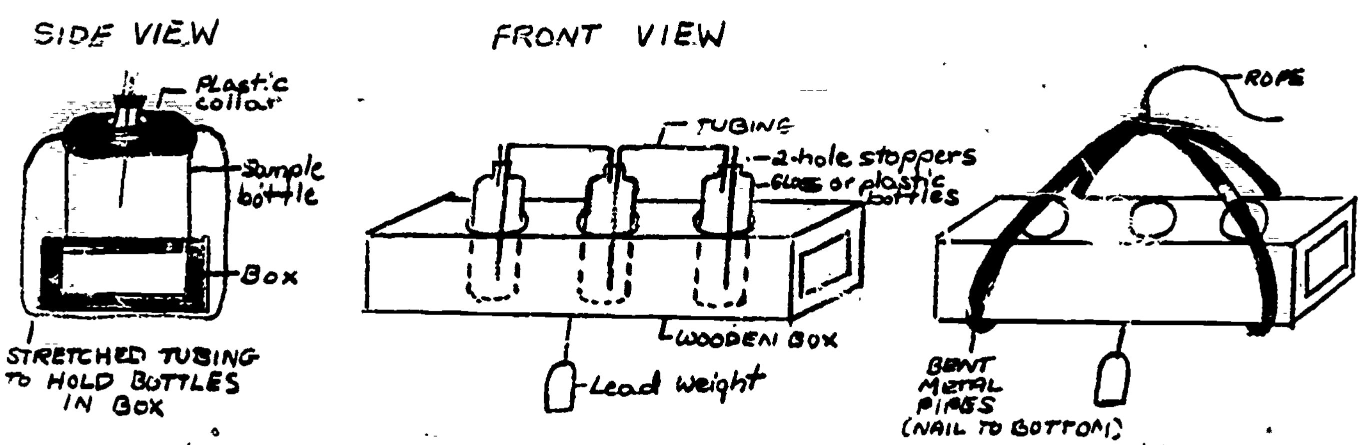
LaMotte offers individual test kits for any chemical analysis. For example, their kit to determine total hardness costs $7.50, phosphate costs $35.00.

Water Analysis Manual by Dr. Charles E. Renn, provides technical information concerning the performance and interpretation of the most commonly determined chemical analyses (written primarily to be used with the LaMotte test kits).

Cost: $.50

Published by: Educational Products Division
LaMotte Chemical Products Company
Chestertown, Maryland 21620

Water sampling bottle:
LaMotte sells one for $24.95 (code 1060), however your local water plant operator can show you how to make your own, or lend you theirs.



Thermometer:
Even an inexpensive indoor-outdoor type is adequate.

II. Bacteriological Analysis of Water

See page 128 for listing. We suggest you visit your hospital; water plant; county health department; nearest office of the Board of Water and Air Resources, Department of Natural and Economic Resources (in North Carolina); or nearby university. Any of these would probably loan you equipment, sterilize your media, and give you enough of the dehydrated E.M.B. and Nutrient Broth to perform the fecal coliform analysis.

SUPPLEMENTS

Part A

Part B and C

UNIT III: SCIENTIFIC ANALYSIS OF LOCAL WATER QUALITY

PART A PLANS

Chemical Analysis

TIME: approximately 7 periods

SUGGESTED ACTIVITIES

Day 1: The day prior to this activity request students to bring colored pencils or crayons to class. Also have available a map of the local major waterways (either a map of the county, a map of the major areas served by the sanitary sewer system or a map of the storm drainage system). All can be obtained from the local city council and it is most helpful to have all three maps.

A local authority (a biology professor, a representative of the E.P.A., or a person from the State Water and Air Resources Commission) with whom you have discussed your plans prior to the visit, spends a class period with the students. The speaker should interact with the students in helping them build a base map showing (1) the classification of local waterways (color coded on the map) according to those set down in "Rules, Regulations, Classifications and Water Quality Standards Applicable to the Surface Waters of North Carolina", as adapted by the North Carolina Department of Water and Air Resources; and (2) the local trouble spots using a different color to show the industrial, domestic, and agricultural centers. He should also identify the kinds of pollutants that are prevalent in the study areas and suggest methods for improving and maintaining local water quality.

ALTERNATIVE:

Naturally, if you are unable to obtain a speaker, you can cover the same information with your students. It would be helpful to have the following maps to give to the students during the discussion: map of the area served by the sanitary sewer system and a map of the storm drainage system (both these maps can be obtained from your local city council).

Day 2: A class period may be spent driving the students through a pre-determined route so they can better visualize the local waterways and trouble spots on their maps; perhaps the students will even be able to add data to their maps. Tracing paper could be used to make overlays showing routes of entry of different pollutants into the waterways (e.g. pesticide routes could be drawn on one piece of paper, detergents on another, and sewage on still another).

Day 3: A planning period is now needed to decide what water tests the students want to run and where they want to obtain their water samples. Refer to the North Carolina Standards for Water Quality, your own time allotment and budget to decide what tests to run. It is possible that the local university, city water plant, or local Board of Water and Air Resources could give you the equipment to use or perhaps wou'd run the tests for you. There is value in the students conducting the tests themselves. However, students who have had limited lab experience and skills may become "bogged down", and you'll need to allot a major portion of time to this section, and thus place less emphasis on the last unit. Either way, the students gain new experiences and learn tremendously; it's simply a matter of where you want to place the emphasis and how controlled you wish to have the class!

The following is an example of possible tests to be run and testing sites:

We are going to run the following analysis at three sites (above, at, and below the pumping station for the city of Washington) in Tranters Creek to determine the impact of the city on the quality of the Pamlico River:

I. odor, floating solids, color (no equipment necessary)
II. pH, temperature (measure in the field); dissolved oxygen (is fixed in the field to prevent further uptake of oxygen)
III. (nitrite, nitrate) nitrogen, total phosphates, turbidity, total hardness
IV. bacteriological analysis of the water (fecal coliform) to be made at a separate time.

The water samples will be collected the morning of the tests and each class will only analyze one sample. Before the chemical and bacterial tests can be performed, there are certain pieces of equipment, terms, and techniques you will need to know. We will begin on these now.

Day 4: The students are to practice the techniques employed in preparing and performing the water analysis. A teacher demonstration could be used or student stations could be set up. Directions for the student stations are given in supplement #20. Depending upon the students' abilities and lab experiences, a period (55 minutes) may not be enough time for the students to complete the exercise if you use station set-ups (refer to supplement #20). A quiz may be given on this exercise (optional). Refer to supplement #21.

Day 5: Prior to the class the students should be given supplement #22, Performing the Lab Analysis of Local Water Quality. During class the students should practice (not actually doing the tests) using the test kits. Each student should practice at least three tests, more if time permits. The test kits can be obtained from LaMotte Chemical Company, Chestertown, Maryland, 21620.

Day 6: The water samples to be tested should be taken prior to class time and taken on the same day as they are to be tested. (Yes, it may mean an early rising! Another factor to consider is that it's mighty cold in January!)

Also prior to class it is most helpful if stations are set-up for the various tests, with the chemicals and necessary equipment placed at the appropriate place.

During class the students should follow the instructions and perform the test(s) they have been assigned to do. Naturally if you have a large class several students will have to work together per test. As the students complete their tests, have the data placed on a chart similar to the following (the chart can be placed on the board prior to class and filled in as the data is collected):

Class	Sampling Site	Temp.	pH	Odor	Turbidity	Nitrites	Nitrates	Dissolved Oxygen	Phosphates (Total)	Coliform bacteria

(If time permits, discuss the results of the tests)

An alternative to the suggestions given for day 5 and 6 would be either a teacher demonstration of the tests or a demonstration given by local water treatment personnel or a chemist. Naturally this alternative would be much less time consuming. The students will benefit from either experience!

Day 7: Continue the discussion of test results. A guide for an explanation of the results would be "Rules, Regulations, Classifications and Water Quality Standards Applicable to the Surface Waters of North Carolina", adopted by the Board of Water and Air Resources, Raleigh, North Carolina and any other available materials on water classification. Do not erase the chart from the board as the results from the bacterial analysis will also need to be recorded on it. (This means leaving the chart on the board for several days.)

An additional activity that could be utilized at this point is contained in supplement #23. Also at this time the students can be given supplement #24, A Manual for the Analysis of Coliform Bacteria in Fresh Water.

UNIT III: SCIENTIFIC ANALYSIS OF LOCAL WATER QUALITY

Part B and C Plans

Bacterial Analysis

TIME: approximately 7 periods (B) and approximately 2 periods (C)

SUGGESTED ACTIVITIES:

Day 8: Prior to this period the students should have read over the manual for bacterial analysis and have some vague idea of what will be done in the bacterial analysis of the water sample. It would be helpful if some time were spent discussing the bacterial analysis, such as why it's being performed (theory). During this period the students could be divided into several groups as follows:

Group No.	Activity
1	prepare the water sampling bottles (refer to page 110)
2.	prepare the Double Strength Lactose Broth (DSLB) refer to page 129 of the manual
3	prepare the Single Strength Lactose Broth (SSLB) refer to page/130 of the manual
4	prepare the Eosine Methylene Blue Agar (EMB) refer to page 130 of the manual

Each group should read the directions given in the manual very carefully, becoming familiar with exactly what they are to do on Day 9 and how to use the equipment. The students may practice without mixing any chemicals. (Naturally you will need to have the equipment available for Day 9.)

Day 9: Each group is to complete within the period the necessary preparations (refer to Day 8).

Note: store the preparations in the refrigerator until used

The students should remain in the same groups but each group will have the following preparations to practice on Day 10 (once again this will be a "practice" day):

Group No.	Activity
1 & 2	following the directions given on pages 132 through 134 of the manual practice performing the initial test
3 & 4	following the directions given on pages 135, practice performing those activities given

Naturally you will need to have the equipment available for student use (refer to the manual for the necessary materials). Each group should read the directions given in the manual very carefully becoming familiar with exactly what they are to do on Day 10. You could use water blanks instead of tubes of broth.

Day 10: Each group is to practice performing those tests they're responsible for (if you wish to expose all the students to all tests then have fruit basket turn over on Day 11; that is, simply reverse the group activities or if you do not wish to spend an additional day have each group explain what they did); remind the students that on Day 11 they'll be performing the actual tests

Day 11: Prior to class, teacher (and students) collect water samples; during class the students perform the tests in groups (if a group finishes early then they can observe others); the students should read pages 136 - 140 in the manual prior to Day 12.

Yes, Days 5 through 11 can be nerve-racking for the teacher. Yes, a lot of time can be saved by you making the preparations yourself, but the students enjoy the experience and many valuable skills and much knowledge are gained!

Day 12: As the coliform test will continue for three or four more days, the students should remain in the groups. Each group should be assigned certain responsibilities.

For example:

Group No.	Activity
1	this group should check for gas production in Initial Test tubes after 12 and 24 hours, the results should be recorded as explained in the manual on page 137
2 & 3	this group should perform the confirmation test as explained on pages 134 and 135
4	this group should check the EMB plates and record the results as explained on page 138

Time could be allotted at the beginning of each period for the students to perform their activity, record results, and have a follow-up discussion. Naturally after completion of the Confirmation Test the results should be recorded on the chart (refer to Day 6), evaluation and discussion of the results should follow (this may require one period to complete).

Part C

If the entire period is not required for the students to perform their activity and record the results then the remainder of the period may be spent on either of the following activities:

Activity #1: during the remainder of the period the students could answer the questions given in supplement #25

Activity #2: as a result of their analysis of their drinking water the students have gained a wealth of knowledge of some of the problems existing in their town. This would be an appropriate time for the students to decide on a target problem in their town they would like to study in depth. Try to get the students to zero in on the major problems, their idea for solving the problem, their plans, and reasons for solving the problems. Some examples of possible projects are given in Appendix I (this would be very useful in the class discussion and as a tool for directing the students in the discussion). Once the students have decided on a project invite an authority to class to discuss possible practical plans for solving the problem the class has selected as the project.

Student research of their project is excellent in Unit IV.

SUPPLEMENT [illegible]

Student Station D[illegible]

To the Teacher

The directions can be written on [illegible] paper and placed at the [illegible] for equipment [illegible] minimal. A list of equipment [illegible] each station.

STATION #1. Cleanliness

In these experiments all equipment must be [illegible] clean. We are testing [illegible] present every where but we want to know [illegible] how much is present in our water sample [illegible] your fingers [illegible] detergent, or the [illegible] sample. Always rinse all tools and equipment in DISTILLED WATER.

Directions: Read, then [illegible] information that's in the box.

Equipment: student [illegible] distilled water

STATION #2. Use of Chemicals

These chemicals are [illegible] dangerous [illegible] skin that contacts them. Handle with care. Always [illegible] all bottles immediately after use [illegible] doesn't get in, and chemical vapors don't get out. Don't CONTAMINATE chemicals by touching dropper tips to anything or by putting a dirty [illegible] into the bottle.

Directions. Read, then copy all the information that's in the box.

Equipment: several [illegible] chemicals used in the actual tests [illegible]

STATION #3: How to use a Balance

1. Set all weights on zero. [illegible] should be at zero. If it is not, [illegible] until the [illegible] zero.
2. Place a small [illegible] paper on the pan.
3. Set all weights on [illegible]. Be sure they CLICK into place.

Supplement #20 (Cont.)

4. If the balance arm does not point to zero, move the lightest weight to the right until the arm points to zero. Read the value of the weights and record the value.
5. Add the weight of the paper to the amount you need to weigh. Move the weights along the scales until they read the weight you want.
6. Gently tap the chemical you wish to weigh onto the paper (don't use a spoon) until the balance arm again points to zero. If you add too much chemical, throw out the extra. DON'T put it back into the jar. Recap the jar.
7. Practice by weighing the objects set out by the teacher.

Directions: Read, then summarize all the information that's in the box. Practice using a balance. Record the weight of all the objects weighed.

Equipment: 5 balances, paper cut into squares (3" x 3"), several jars of chemicals, empty beaker or bowl for waste chemicals several objects (at least three) to be weighed

STATION #4: Pipettes

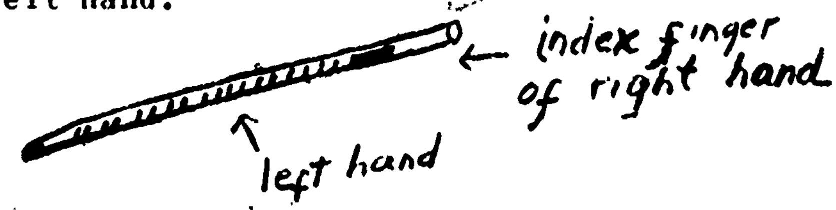
Pipettes are used to measure, very accurately, small quantities of water or other liquids. Be careful with them - they're very EXPENSIVE;
the tips break easily;
they can roll off tables.

To use:

1. Hold the pipette in your writing hand. Insert the pipette carefully into the liquid. DON'T bang the tip on the bottom of the beaker or jar!
2. Place your mouth on the pipette. Slowly draw up the liquid as you would on a straw in milk, but WATCH so you stop before the liquid reaches the TOP!
3. Quickly remove your mouth and push your index finger over the opening to hold the liquid in the pipette.

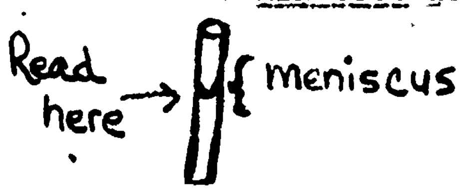
Supplement #29 (Cont.)

4. Hold the pipette at a slant, supporting it with your left hand.



Release your index finger just enough to allow the liquid to flow out. Stop the flow when it reaches the zero mark by pressing your index finger hard over the opening. Hold the pipette at eye level to read it.

5. Read where the bottom of the MENISCUS hits the mark.



6. Dispense (release) as much liquid as you need.

Directions: read, then summarize all the information that's in the box ☐ . Practice using a pipette. Cover the mouth-piece with saran wrap as these pipettes have not been sterilized.

Equipment: several pipettes of different volumes, saran wrap or paper towels, jars of tap water

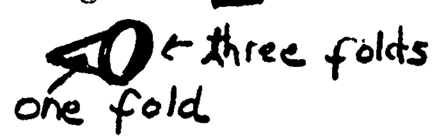
STATION #5: Filtration

Folding Filter Paper:

1. fold the filter paper in half 

2. fold the filter paper in half again 

3. open one end to form a cone



4. insert cone in the funnel

5. set in the tripod

Filtration:

1. Before filtering your water sample, rinse the filter paper with distilled water and discard (throw away) the filtrate (the water that comes through the filter).

Supplement #20 (Cont.)

Directions: Read, then summarize the information in the box. Practice folding filter paper and filtering a water sample.

Equipment: filter paper or plain paper cut in circles, a water sample, beaker, tripod, distilled water.

STATION #6: Accuracy

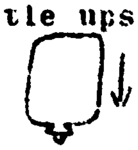
The chemical tests we will do will only be accurate if you read the directions and follow them exactly. All measurements must be exact. There are two measurements which require special attention:

1. dropper bottles
2. microburettes

Dropper Bottles

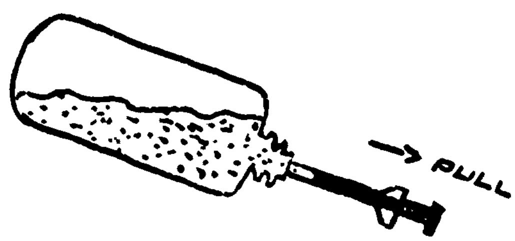
1. To measure drops, turn the bottle upside down, not at a slant.

2. Squeeze and count each drop.



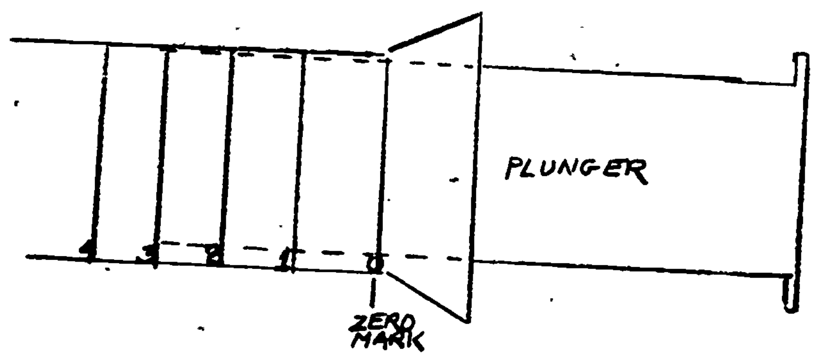
Microburette

1. To fill, push the plunger in all the way to push out all the air from the barrel.
2. Push the tip of the burette into a bottle of reagent.
3. Turn the reagent bottle upside down so the liquid touches the tip of the burette.

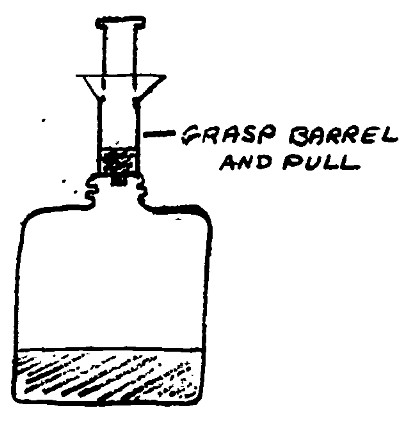


Supplement #20 (Cont.)

4. Pull slowly on the plunger to draw out the reagent (liquid in the bottle).
5. Keep filling the burette until the liquid touches the zero mark.



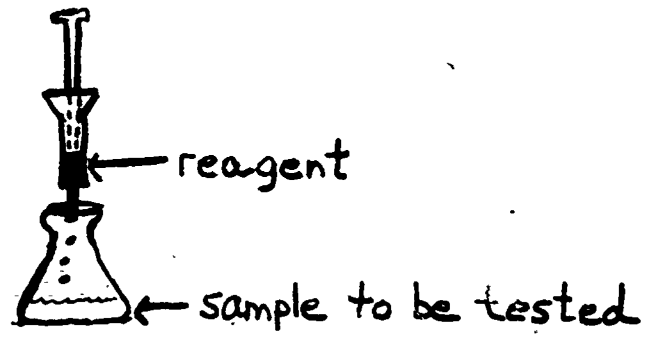
6. Turn the bottle right side up before removing the burette.
7. Grasp the burette on the barrel and pull out of the bottle; wipe any liquid off the tip of the burette.



8. Recap the bottle of reagent.

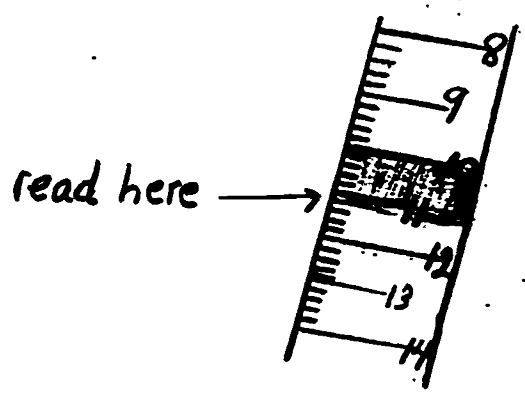
Supplement #20 (Cont.)

9. To use the burette (to "titrate"):
   a. insert the burette tip into the cap of the flask holding the sample to be tested
   b. push, using a twisting motion, the plunger with your hand
   c. add only a drop at a time
   d. mix the sample well after each drop is added



   e. How to read the amount used:
      - notice each major division is divided into minor divisions
      - each large (major) division equals 0.2 parts per million (ppm) dissolved oxygen (D.O.)
      - each small (minor) division equals 0.04 parts per million (ppm) dissolved oxygen

      Note: The values given are for the test for dissolved oxygen only. Other tests using the microburette have different values.



answer is:

$11 \times 0.2 = 2.2$ ppm

$1 \times 0.04 = 0.04$ ppm

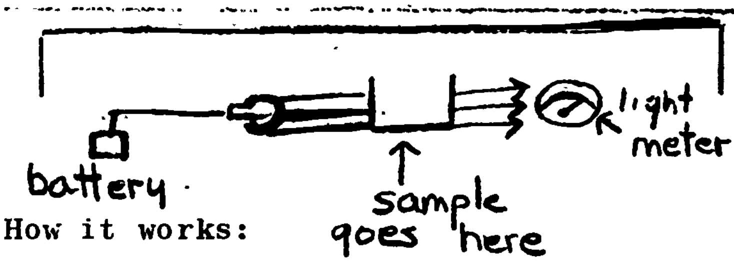
2.24 ppm D.O

Directions: Read, then summarize the information that's in the box ☐ . Copy the information given in 9 (e). Practice using a dropper bottle, a microburette and titrating with a microburette.

Equipment: dropper bottle, microburette, reagent bottle, flask with hole in the cap, jar of water, paper towels

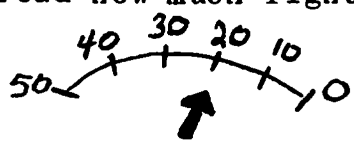
Supplement #20 (Cont.)

STATION #7: Photometer



How it works:

There is a light bulb in the housing and a light meter opposite it. The brighter the light, the more current is produced by the light meter. The current produced is read on the scale (0 to 50). If you put your sample in the path of the light, it will block some of the light. You will read how much light is blocked on the scale.



How to use it (the photometer):

Check to see that the meter needle points to 50 on the scale when the button is not pressed. If not, adjust to 50 by rotating the screw in the meter cover. Use only the glass test cells provided to test the sample in. Fill the cell at least to the mark (this is 10 ml.). The cells <u>must</u> be clean, dry, and free of finger prints. Hold the cell toward a light to check for dirt and grease before putting it in the meter. Carefully pour your sample into a test cell just before using the photometer.

Each experiment requires you to prepare a "blank". This is a solution, often plain water, that you fill a test cell with and insert into the photometer. Next, you place the <u>correct</u> filter into the slot. Press the buttom (push the button only long enough to make a reading so the lamp and battery will last longer). Turn the knob to set the needle to zero. Quickly release the buttom and remove the blank. Replace the blank with the sample. Press the button and read the value on the scale (do not turn the knob). Release the button quickly!

What is it used for:

The photometer is used to test for turbidity, phosphates, and nitrates.

Supplement #20 (Cont.)

Directions: Read, then summarize the information that's in the box $\boxed{}$. Practice using the photometer.

Equipment: photometer (Delta Scientific Corporation), water sample (this can be from the river the class polluted earlier)

STENCIL

SUPPLEMENT #21

A Quiz on Laboratory Techniques and Key

Name________________________

Period________________________

Directions: Place the correct answer on notebook paper.

I. Multiple Choice

1. The object below is: (a) a microburette; (b) a pipette; (c) a beaker; (d) a funnel

2. The use of the object in #1 is: (a) to measure small amounts of water or other liquid very correctly; (b) to filter water samples (remove much of the solid materials), the filter paper must be put in this object; (c) to test for turbidity, nitrates, and phosphates; (d) none of these

3. When filtering a water sample, the water that comes through the filter paper and is collected is called the: (a) meniscus; (b) filtrate; (c) water sample; (d) waste water

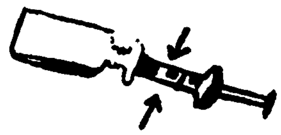
4. Before filtering a water sample, you should always rinse the filter paper with: (a) polluted water; (b) sulfuric acid; (c) lime; (d) distilled water

5. The object below is: (a) a funnel; (b) a microburette; (c) a pipette; (d) a balance

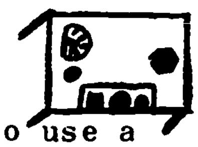
6. All lab equipment needs to be cleaned before using it in a lab because: (a) we are testing the <u>exact</u> amount of chemicals present in our water sample (not on our fingers or lab equipment)!; (b) we are testing for the presence of certail chemicals and if some of the equipment is contaminated our results would be affected; (c) both of these; (d) only b

Supplement #21 (Cont.)

7. The object at the tip of the arrow is: (a) a balance; (b) a pipette; (c) a photometer; (d) a microburette



8. The object below is: (a) a balance; (b) a pipette; (c) a microburette; (d) a photometer



II. Grouping

9 - 13 Arrange the following steps of how to use a pipette in the correct order: (Number 1 - 5)

9. Quickly remove your mouth and put your index finger over the opening.

10. Hold the pipette in your writing hand. Insert the pipette into the liquid.

11. Hold the pipette at a slant and release enough to allow the liquid to flow out.

12. Place your mouth on the pipette.

13. Slowly draw up the liquid as you would when drinking milk with a straw.

14 - 19 Arrange in order the steps involved in using a balance: (Number 1 - 6)

14. Place square of paper on the balance pan.

15. Set all weights on zero.

16. With the paper on the pan move the weights until the balance arm points to zero.

17. Gently tap the chemical you wish to weigh onto the paper already on the balance pan.

18. Check to see that the balance arm points to zero.

19. With the chemical on the paper move the weights until the balance arm points to zero.

Supplement #21 (Cont.)

III. Short Answer

20. How much liquid has been released? (Note diagram on the board)

21. What is a photometer used to test for?

22. Explain exactly how to use a dropper bottle.

23. Using object A weigh and record the weight of: (note the board)

24. Note the diagram on the board. Record the weight shown.

25 - 28 Identify the objects held by your teacher.

29. Fold a piece of filter paper correctly and staple it to the test as if it were being put in a funnel.

30. When you complete the test begin reading the sheet on chemical tests.

KEY

I. Multiple Choice

1. d
2. b
3. b
4. d
5. c
6. c
7. d
8. d

II. Grouping 9 - 13

9. 4
10. 1
11. 5
12. 2
13. 3

Grouping 14 - 19

14. 3
15. 1
16. 4
17. 5
18. 2
19. 6

III. Short Answer

20. Place a drawing on the board of a pipette with a certain amount of liquid in it.

21. To test for turbidity, nitrates, and phosphates.

22. Turn the dropper bottle upside down and squeeze; count each drop; do not let the bottle slant, always keep it at the same angle for each squeeze.

23. Place a balance on each table and have each student weigh an object and record the weight.

24 Place a drawing of a balance on the board showing the weight of object X; the students record the weight of object X.

25 - 28 The students are to identify three objects they have learned how to use (e.g. a pipette, a funnel, and filter paper).

29. Check to see that the student's filter paper is folded properly and pinned to the answer sheet as if it were in a funnel.

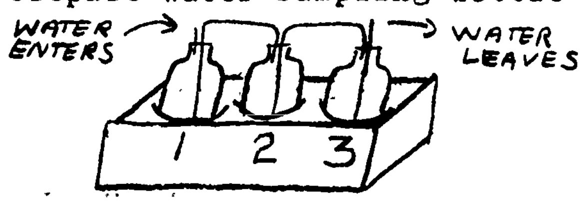
30. Refer to supplement #22.

SUPPLEMENT #22

Collection of Water Samples

The professional method for collecting water samples:

1. Prepare water sampling bottle apparatus:



2. Lower bottles to one-half to two-thirds of the water's depth in the main water flow (if a moving body of water). Do not collect water near the edge since the water will be stagnant and not representative.

3. Raise bottles:
   a. Fix bottle no. 1 (see directions in the dissolved oxygen kit). Label: for D.O.
   b. Label bottle no. 2: for chemical analyses.
   c. Discard water in bottle no. 3.

For simplicity, any type of clean bottle may be lowered, but:

1. Collect one full bottle for the dissolved oxygen test (no air space to shake more oxygen in it as it is collected) and fix immediately.

2. Collect a bottle for the remainder of the tests.

Note: After a heavy rainfall, the concentrations of many pollutants will be much greater than before due to air pollutants being washed down and land run-off. Also, many sewage treatment plants don't work as well during heavy rainfalls. Professional water quality monitors do not take water samples right after it has rained (for 2 or 3 days). However, it may be very meaningful to find out how much pollution is actually caused by land run-off.

STENCIL

SUPPLEMENT #22

Performing the Lab Analysis of Local Water Quality

SAMPLING SITE__________________

DATE______________________

NO. DAYS SINCE LAST RAINFALL__________

PROCEDURES

I. TO BE PERFORMED AT THE SAMPLING SITE

RESULTS:	1. Measure surface temperature and temperature as far down as you can reach.
Surface temp.______ Deep temp.________	NOTE: Hold the thermometer in the water until the fluid stops moving. Remove the water, hold at eye level, read quickly.
________________ ________________	2. Describe the appearance of the water (littered, oily, clear, cloudy, etc.).
pH________________	3. Measure the pH as directed.
	4. "Fix" a sample (see test kit) to stop any more oxygen use by organisms and chemicals. The amount of dissolved oxygen will be measured in the lab.

II. TO BE PERFORMED IN THE LABORATORY

ODOR:______________ ________________ COLOR:_____________ ________________	1. Odor and Color: Shake the sample bottle. Pour about 50 ml. into a small beaker. Describe any odor as best you can. Set the beaker on a sheet of white paper and then describe the color of the water in the beaker.

Supplement #22 (Cont.)

METER VALUE: ________________

2. Turbidity:

a. Shake the sample bottle. Pour the sample into a test cell. Replace the cap. Clean outside of test cell thoroughly.

b. Fill a second clean test cell with distilled water. Replace cap. Clean outside.

Turbidity (from graph): ________________ ppm

c. Insert the filter holder into the photometer (all the way) so that the BLUE dot faces up.

d. Insert cell with distilled water into the photometer. Press button and turn knob to set meter to 0, then release button switch.

e. Remove cell and replace with cell containing the sample. Press button and when water comes to rest, read meter value.

*obtain from your teacher

f. Refer to *graph to obtain turbidity in parts per million (ppm).

g. Rinse cells thoroughly with distilled water.

3. Nitrites

METER VALUE: ________________

____

a. Mix sample bottle by inverting and letting stand 1 minute. Fill a clean test cell to the mark with sample.

b. Use no. 33 scoop. Add 1 level scoopful of reagent no. 47. Rinse the scoop, dry, replace. Cap the cell and shake to dissolve. Note the time and let stand 5 minutes. Always replace cap promptly and tightly on the reagent bottle to prevent the powder from absorbing moisture in the air. Clean outside of the test cell.

Supplement #22 (Cont.)

GRAPH:

_______________ppm

c. Prepare a "blank" by adding distilled water to the mark of a second test cell. Clean outside of cell.

d. Insert the cell containing the blank into the photometer.

e. Insert filter holder into the slot with ONE GREEN DOT facing upward.

f. Press the button and turn knob to set meter to 0. Promptly release switch.

g. Remove cell. Replace with cell containing treated sample (after 5 minutes). Press button and when meter needle comes to rest, read meter value.

h. Refer to graph to obtain results in parts per million nitrogen.

i. Rinse test cells.

4. Nitrates

METER VALUE:

____

GRAPH:

_______________ppm

a. Fill a test cell to the mark with mixed sample to be tested.

b. Add 2 drops reagent no. 54 (chlorine) and 3 drops reagent no. 5 (sulfuric acid). Shake 30 seconds. Let stand 2 minutes.

c. Add 1 drop reagent no. 48 (sodium arsenic). Mix for 30 seconds.

d. Using no. 33 scoop add 1 level scoopful reagent no. 46. Rinse and dry scoop. (Cap the cell. Shake vigorously for 30 seconds.) Note the time and let stand 5 minutes.

e. Prepare a "blank" by adding 10 ml. distilled water to a second test cell.

Supplement #22 (Cont.)

f. Mix the treated sample once by tilting upside down and back. Let stand 1 more minute.

g. Insert the filter holder into the photometer so that ONE GREEN DOT faces upward.

h. Insert the cell containing the "blank" into the photometer. Press button and turn knob to set meter to 0. Promptly release button.

i. Remove cell and replace with cell containing treated sample.

j. Press button and when meter needle comes to rest, read meter value. Record.

k. Refer to graph to obtain results in parts per million nitrate nitrogen.

5. Dissolved Oxygen

DISSOLVED OXYGEN

_______________ppm

a. Fill flask with sample that was "fixed" in the field to stop further oxygen use.

b. Using the microburette, fill burette to top line with sodium thiosulfate and slowly add sodium thiosulfate to the sample until the brown color almost disappears. Mix the sample by swirling carefully after adding each drop. You may have to fill the microburette again. Keep track of how much sodium thiosulfate is used. Don't empty the burette after you add all you need.

c. Add 8 drops of starch solution. The sample will turn blue.

d. Again slowly add sodium thiosulfate until the blue color just disappears. STOP adding the sodium thiosulfate.

Supplement #22 (Cont.)

e. NOTE the reading on the microburette.

f. Write down how much dissolved oxygen (D.O.) was in the sample according to the following:

each large graduation = 0.2 ppm D.O.
each small graduation = 0.04 ppm D.O.

6. <u>Phosphate</u>

FIRST FILTER THE WATER TO BE TESTED:

TO FILTER:

a. Mix river water and pour out about 50 mL of the water sample.

b. Fold a piece of filter paper in half.

c. Fold the filter paper in half again.

d. Open 1 side to form a funnel shape.

e. Place paper in funnel set on tripod and wet paper thoroughly by pouring distilled water through. Be sure you have a beaker under the funnel to collect the water!

f. Discard the water you collect.

g. Now place a clean dry beaker under the funnel and pour the water sample to be tested into the funnel. Collect the filtrate.

h. LABEL the beaker of filtrate: "Period (<u>2, 3, or 4</u>) Filtered Sample"

Supplement #22 (Cont.)

TO DETERMINE THE AMOUNT OF ORTHOPHOSPHATES:

METER VALUE: ____________

FROM GRAPH: ____________ppm

a. Fill a test cell to the mark (10 ml.) with the FILTERED sample.

b. Also fill another test cell with distilled water. This is the "blank."

c. Add 10 drops of reagent no. 41 (sulfuric acid) to each and mix.

d. Add 6 drops of reagent no. 39 (ammonium molybdate) to each and mix.

e. Add 1 drop of reagent no. 40 (stannous chloride) to each and mix.

f. Allow to stand 15 minutes for full color development.

g. Insert filter holder in photometer so that YELLOW DOT faces upward.

h. Insert cell containing the "blank" into the photometer. Press button and turn knob to set meter to 0. Promptly release switch.

i. Remove cell and replace with cell containing treated sample. Press button and when meter needle comes to rest, read meter value.

j. Obtain results in parts per million orthophosphate from *graph.

Supplement #22 (Cont.)

TO DETERMINE THE AMOUNT OF TOTAL PHOSPHATE:

METER VALUE: ________________

FROM GRAPH: ________________ ppm

a. Measure 10 ml. of FILTERED sample into a small beaker or Erlenmeyer Flask.

b. Add 10 drops of reagent no. 41 (sulfuric acid) and mix. Mark level of liquid with wax pencil.

c. Allow acidified sample to boil gently for 90 minutes adding distilled water to keep the volume to 10 ml.

d. Cool sample and transfer to test cell. Dilute with distilled water to 10 ml. mark.

e. Also prepare a reagent blank by adding 10 ml. distilled water to a test cell and add 10 drops, reagent no. 41.

f. Add to each, while mixing, 6 drops of reagent no. 39 and one drop of reagent no. 40. Let stand 15 minutes for full color development.

g. Continue as directed in procedure for orthophosphate, beginning with step g.

POLYPHOSPHATE: ________________ ppm

To determine the amount of polyphosphate, substract result obtained for orthophosphate from result obtained for total phosphate.

7. Hardness

Turbid samples should be filtered to remove scale, sludge, rust, etc. before making tests. This is necessary because even small traces of suspended matter may affect test results. To filter the sample, fit the filter paper to the funnel, moisten with the sample and press down tightly to the sides of the funnel. Fill with the sample but not quite to the top. Collect the

Supplement #22 (Cont.)

water going through the filter in any clean bottle. Discard the first sample that goes through. Now proceed with the following steps:

a. Rinse the no. 8 plastic sample tube well with the clear filtered sample and then fill it to the mark. The meniscus (curved surface) should be level with the mark.

b. Add 5 drops of reagent no. 20 and a dipper (in cap) of reagent no. 21. Mix gently to dissolve the indicator.

c. If hardness is present the sample will be red. If absent, the sample will be blue.

d. If red, add reagent no. 19 a drop at a time, mixing well after each drop. Continue until the sample has no red color but is entirely blue. Keep track of all drops added and always hold the dropping bottle in a vertical position. Each drop is equal to 10 parts per million (ppm) of hardness as $CaCo_3$ (calcium carbonates).

Supplement #22 (Cont.)

Interpretation of Chemical Analyses

1. Temperature: no definite temperature is "good" or "bad". Consider the following, however:

   a. The warmer the water, the less oxygen will be dissolved in it.

   b. The warmer the water, the faster the growth of bacteria, which will deplete (use up) the oxygen supply faster.

   c. All organisms require a certain temperature range in order to live and reproduce. This will vary somewhat.

2. pH: most organisms will only live in a pH range between 5.0 and 8.5.

   a. Natural sea water will have a pH value of 8.1.

   b. The pH of freshwater will be lower than sea water; rainwater may have a pH value of 5.5 to 6.0.

3. Odor: any offensive odor should be viewed with suspicion.

   a. An odor of rotten eggs indicates the presence of hydrogen sulfide which could have come from an industrial plant or anaerobic bacteria. These bacteria may indicate a lot of organic waste in the water and a serious lack of oxygen.

4. Color: the presence of color does not always indicate serious pollution.

   a. Green may mean many algae (consider the possibility of eutrophication).

   b. Brown may mean tannic acid which naturally leaches (dissolves) out from the barks and leaves of trees. This is natural in some areas, especially still bodies of water (like swamps and rivers near swamps).

   C. Brownish red may indicate the presence of iron that may running out from mines. Since leakage from mines would be acid, this red color should be viewed with suspicion.

   d. Any unnatural color may indicate effluent from a dye or textile factory being discharged into the water.

Supplement #22 (Cont.)

5. Turbidity: since this is caused by the presence of suspended particles like clay, silt, organic matter, plankton and other microscopic organisms, consider the following:

   a. erosion - especially bad after a rainfall
   b. excessive amounts of wastes being discharged by storm sewers, city sewage treatment plant, factories

   The Environmental Protection Agency recommends turbidity should not exceed 50 "JTU" in warm water streams or 10 "JTU" in cold water streams. If you use a test kit that measures in JTU, you can evaluate your data according to this recommendation. If you do not, you can compare your measurements with those of a body of water you know to be "unpolluted".

6. Nitrogen:

   a. Nitrogen enters the water as nitrates or nitrites from fertilizers, sewage, storm drains, industrial and packing house wastes, drainage from livestock feeding areas, farm manures and legumes. Excessive amounts of nitrogen, in combination with phosphorous will lead to eutrophication. Also, large amounts of nitrates may be harmful if drunk by humans.

   b. Algal blooms stimulated by nitrogen will occur more rapidly in non-moving or slowly-moving bodies of water.

   c. Many states do not allow more than <u>2 micrograms of nitrogen per liter of water</u>. If your test kit measures in parts per million (ppm), view with suspicion any result above <u>1 ppm</u>.

   d. Keep in mind that there is no known concentration that is definitely known to be "safe". Research is being performed at this time and more definite information should be available in the future.

7. Phosphorous:

   a. Phosphorous, in combination with nitrogen, serves as the stimulus for algal blooms leading to eutrophication.

   b. A small amount of phosphorous is normal. More than 0.1 ppm may indicate wastewater from a sewage treatment plant, storm drains (consider detergents and pet wastes), or drainage from agricultural areas (fertilizer and animal wastes).

c. Refer to no. 6-d above. The same applies to phosphorous.

d. Orthophosphates are readily used by algae while polyphosphates are not. The polyphosphates must be broken down to a simple form before the algae can feed on them. Thus, the orthophosphates represent a more immediate danger. Again, more research is needed in this area of study.

8. Oxygen:

a. Most water organisms (except the "strict" anaerobic bacteria) require oxygen that has dissolved in the water from photosynthesis (produced by water plants like diatoms and algae and even some bacteria) and from the air.

b. Salt water holds less oxygen than fresh water.

c. Oxygen is used up by both living organisms (in respiration) and by chemicals that combine with the oxygen (like the rusting of iron).

d. Warm water holds less oxygen than cold water (think of how the gas bubbles in a soft drink rise to the surface and disappear).

e. Habitats for warm water fish populations should contain dissolved oxygen concentrations of no less than 4.0 milligrams per liter (mg/l).

f. Habitats for cold-water fish populations should be no less than 5.0 mg/l.

g. Swiftly moving streams will get more oxygen from the air than slowly moving bodies of water.

h. There will be less oxygen the lower you collect the water sample. There is often no available oxygen near the bottoms of some lakes.

SUPPLEMENT #23

The Chemical Analysis of Water

Student Worksheet and Key

Directions: Answer the following questions as completely as possible. Use the scientific bibliography and any notes you may have taken.

Questions:

1. Why are we performing chemical tests on the water sample?

   answer: to determine exactly what substances are present in the water

2. How will we find out what our results mean?

   answer: by comparing our results with those given in +"Rules, Regulations, Classifications, and Water Quality Standards Applicable to the Surface Water of North Carolina"; also by consulting local water quality officials

3. What is the difference between ground water and surface water?

   answer: ground water is usually pure water* flowing beneath the surface of the earth; whereas surface water is that which accumulates on the earth's surface and is relatively impure water

4. What specific chemical tests are we performing?

   answer: this depends on the class and teacher's decisions

5. What are the five classifications of surface water? Give the characteristics of each.

   answer: refer to +"Rules, Regulations, Classifications and Water Quality Standards Applicable to the Surface Water of North Carolina", adopted by the Board of Water and Air Resources Commission, Raleigh, North Carolina

6. What is the classification of the following: (a) Jack's Creek, (b) Tranter's Creek, (c) the Pamlico off Stewart Parkway?

   answer: this question will need to be revised so that it is applicable to your local situation

+or similar regulations for your state
*may become contaminated as it flows under sources of contamination such as sanitary landfills or septic tanks

SUPPLEMENT #24

A MANUAL FOR THE ANALYSIS OF COLIFORM BACTERIA IN FRESH WATER

Compiled and Distributed by
Environmental Science Study Curriculum
P. S. Jones Junior High School
Washington, North Carolina 27889

Modified From: Standard Methods of the Examination of Water and Sewage American Public Health Association, 1928

INTRODUCTION

This exercise, the analysis of water to determine the presence of fecal coliform bacteria, is structured to accommodate students in grades eight and up. This study not only offers results in terms of analysis, but also gives students experience with a totally "hands on" procedure. Laboratory skills from accuracy, measuring, pipetting to the more advanced skills of sterilization techniques and inoculation are emphasized in this exercise.

THEORY

Water that contains large numbers of bacteria may be perfectly safe to drink, but it depends on what kind of bacteria are present. (Remember, bacteria are tiny plants made up of a single cell and only visible by magnifying at least 500 to 1000 times.) Bacteria in water play a very important role: they feed on organic waste, breaking them down into simple chemical nutrients to be utilized again. Bacteria are mainly decomposers.

Some bacteria cause diseases. These bacteria are called pathogens. Examples of pathogenic (pa - tho - ge-- nic) bacteria present in the human intestinal tract are those that cause typhoid fever, cholera, and bacillary dysentery. Obviously, if a person has any of these pathogens in his intestinal tract, his feces will contain large numbers of these bacteria. You can now understand why it is so important to treat sewage before releasing it into our waterways. Anyone coming in contact with water containing untreated sewage or poorly treated sewage is in danger of being infected by these bacteria.

Of course, not all sewage contains these pathogens. These bacteria are hard to detect because they do not grow well outside the human body. Therefore, it would be impossible to test all sewage to see which samples are contaminated. However, scientists have a clever method of determining whether or not a water supply may contain some of these pathogens. They simply test the water for the presence of non-pathogenic bacteria which are normally present in the human intestines, and thus in human feces. The bacteria the scientists test for grow readily in the laboratory and are easy to find. These bacteria are called "coliform bacteria". Thus, if non-pathogenic intestinal bacteria (fecal coliform) are present, there may also be pathogenic bacteria present.

The Standard Bacteriological Analysis of Water you are performing, tests for the presence of fecal coliform bacteria in a simple manner. The coliform bacteria, unlike other intestinal bacteria, feed on lactose sugar (the sugar in milk) and release carbon dioxide gas as a waste. You will be able to see this gas trapped in a tiny tube stuck upside down in the culture tube if the bacteria are present. A second test (just to be sure) involves growing the coliform bacteria on a special medium (called EMB) on which the *bacteria becomes colored a metallic green**. A third test (just to be positive) involves observing these bacteria with a microscope after staining them with a special dye which colors the coliform pink and certain other bacteria, commonly present in water, purple.

The analysis you are doing is the accepted standard method (published by the American Public Health Association, Inc.) for the State of North Carolina by the Board of Water and Air Resources, Department of Water and Air Resources. It has not been simplified for you in any way!

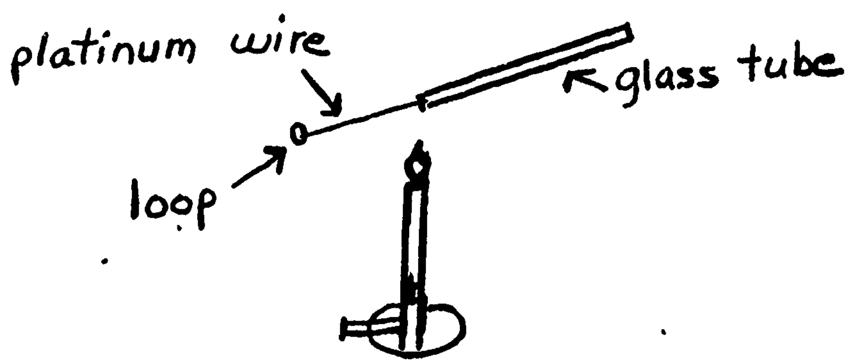
*The particular fecal coliform being tested for is <u>ESCHERICHIA COLI</u> (ES - CHER - I - CHI - A KO - LI)

** Common coliform bacteria found in the soil, <u>AEROBACTER - AEROGENES</u>, will become colored pink on EMB.

Inoculating Loops and Incubator

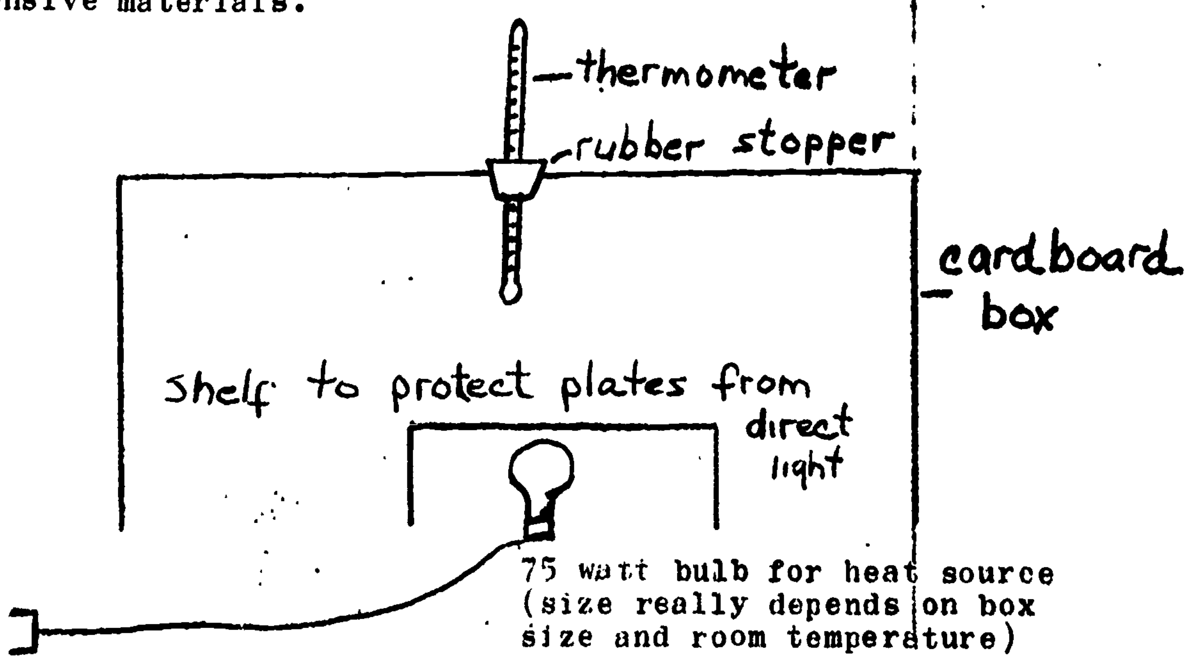
Inoculating Loops

The inoculating loops can be made very easily. Insert a three-inch piece of wire (such as platinum) that heats and cools rapidly, about one-half inch into a six-inch piece of small glass tubing. Melt the end of the glass tubing until it closes and firmly holds the wire. Fire polish the other end to avoid injuries. On the end of the wire make a small loop about two to four mm. in diameter (shape the wire around the point of a pencil).



Incubator

The incubator can be made of readily available and inexpensive materials.



Sterilization of Glassware and Liquids

Sterilization of Empty Glassware

1. Wash the empty glassware with a non-phosphate, biodegradable soap, and rinse well; dry or let drain until dry.
2. Stopper the clean glassware with a cotton plug or cover the neck with aluminum foil (if a cotton plug is used, cover it with aluminum foil or brown paper and tie with a string); if the glass bottle is to be shaken, loosely set a rubber stopper in the neck.
3. Label the glassware with masking or autoclave tape.
4. Autoclave at 15 psi, 121°C for 15-20 minutes.
5. Store the sterilized glassware where the items will not be disturbed until used.

Sterilization of Liquids

1. Prepare the liquid in a heat resistant container (pyrex or kimax).
2. Stopper as explained in #2 above.
3. Label with masking or autoclave tape.
4. Autoclave at 15 psi, 121°C for 15-20 minutes.
5. If the liquid is an agar medium to be poured into petri plates, swirl the flask to mix the contents (don't produce bubbles), allow to cool until the flask can be handled comfortably.
6. Store in the refrigerator until used.

*Do not open the escape valve. Allow the pressure to drop slowly to prevent the liquid from boiling over.

STANDARD BACTERIOLOGICAL ANALYSIS OF FRESH WATER (MODIFIED VERSION)

EQUIPMENT AND MATERIALS FOR INITIAL AND CONFIRMATION TESTS

The purchasing of all the initial materials for the bacteriological tests may be above your available funds. If you are near a university or community college, you may be able to borrow much of the equipment. If these sources are not available, try your local water treatment plant or hospital.

A. The following materials are needed for each water sample tested:

1. 2 (500 ml.) flasks
2. 1 (10 ml.) pipette
3. 2 (1 ml.) pipette
4. 12 small test tubes (6mm. x 50 mm.)
5. 12 medium or large test tubes
6. 15 sterile petri plates with covers
7. 2 (250 ml.) bottles (wide mouth) with rubber stoppers (no holes)
8. 1 (100 ml.) graduated cylinder
9. 1 stirring rod
10. 2 (250 ml.) beakers (or small cans) for holding test tubes
11. 2 test tube racks

*A small tube is inverted in a large tube. The size used is not important, but the amount of broth added must be sufficient to fill the inverted tube (the broth will fill the inverted tube during autoclaving) and still be contained outside the inverted tube.

B. The following equipment is also necessary:

1. balance (accurate to 0.1 g.)
2. ring clamp (optional)
3. funnel, tubing and pinch clamp (optional)
4. tray or cylinder to hold pipette (optional)
5. hot plate
6. bunsen burner (gas supply)
7. non-absorbent cotton
8. brown paper } or aluminum foil
9. string and scissors } or aluminum foil
10. autoclave tape (convenient, not not essential)
11. inoculating loops*
12. bottle of lactose
13. bottle of Nutrient Broth (BBL)
14. distilled water
15. disinfectant
16. Eosine Methylene Blue Agar Medium (BBL)
17. large pressure cooker (or autoclave)
18. incubator**

*Refer to page 126

**Refer to page 127

PREPARATION

These preparations should be completed one to two days prior to the taking of the water sample. It is best to allow the class to do these preparations as much useful experience and many skills may be gained. Depending on the length of a class period, it will not take longer than two periods to make all necessary preparations. This time allotment is based on the students having read the information and practiced the techniques prior to the actual performance. Consequently, you must include that preparation time plus the two periods necessary for the actual preparation of the materials.

A. Preparation of Water Sampling Bottle

1. thoroughly clean and rinse one (250 ml.) bottle (wide mouth).
2. stopper loosely with a rubber stopper (no hole)
3. cover the stopper with aluminum foil
4. label and sterilize (refer to page 127 - Sterilization of Glassware)

B. Preparation of Media and Dilution Blanks

1. Double Strength Lactose Broth (DSLB)
   a. in a 500 ml. flask pour 150 ml. of water
   b. weigh out 3.0 grams of lactose and add it to the water
   c. weigh out 2.4 grams of nutrient broth and add it to the water
   d. swirl (do not shake) and warm gently until the mixture is just dissolved
   e. set 3 large test tubes in a rack
   f. into each one carefully slide a small test tube (6 mm. x 50 mm.) upside down (the tube will float when the media is added but after autoclaving it will sink and be filled with media)
   g. label each tube with masking or autoclave tape marked DSLB in pencil
   h. using a pipette release exactly 10.0 ml. of the broth into each tube (do not discard the remainder of the broth as it is to be used in step 2)
   i. plug each tube with a rolled cotton plug
   j. set the tubes in a beaker or can, cover with aluminum foil or with brown paper and tie with string
   k. autoclave at 15 psi and 121° C (250°F) for 15 minutes (refer to page 127 - Sterilization of Liquids)

2. Single Strength Lactose Broth (SSLB)
   a. to 100 ml. of DSLB remaining in the flask add 100 ml. water
   b. swirl to mix (do not shake)
   c. set 9 large test tubes in a rack
   d. into each one carefully slide a small test tube (6 mm. x 50 mm.) upside down (the tube will float when the media is added but after autoclaving it will sink and be filled with media)
   e. label each tube with masking or autoclave tape marked SSLB in pencil
   f. using either a 10 ml. pipette or the apparatus diagrammed, fill each of the 9 test tubes with 10.0 ml. of SSLB
   g. plug each tube with cotton
   h. set the tubes in a beaker or can, cover with brown paper and tie with string
   i. autoclave at 15 psi and 121°C (250°F) for 15 minutes (refer to page 127 - II-Sterilization of Liquids)

3. Eosine Methylene Blue Agar (EMB)
   a. into a 500 ml. flask pour 250 ml. of water
   b. add 8.0 grams of eosine methylene blue agar (pour the EMB carefully into the water)
   c. swirl, don't bother to dissolve
   d. plug the flask with cotton
   e. cover with brown paper and tie with string
   f. label with masking or autoclave tape marked EMB in pencil
   g. autoclave at 15 psi and 121°F (250°F) for 15 minutes (refer to page 127 - Sterilization of Liquids)
   h. after autoclaving, swirl well but gently (do not shake or make bubbles)
   i. cool down EMB to about 50°C in a water bath or until just cool enough to hold
   j. pour into sterilized petri plates as follows (to insure sterile conditions and no contamination from bacteria in the air this procedure must be used):
      i. clean the work area with disinfectant (lysol or alcohol)
      ii. open the package of sterile petri plates, but DO NOT OPEN any plates
      iii. light the bunsen burner
      iv. remove the paper and cotton plug from the flask being careful not to touch the lip of the flask

v. briefly expose the lips of the flask to the flame and open a plate just enough to pour EMB into the plate; the EMB should cover the bottom surface of the plate

vi. quickly replace the lid

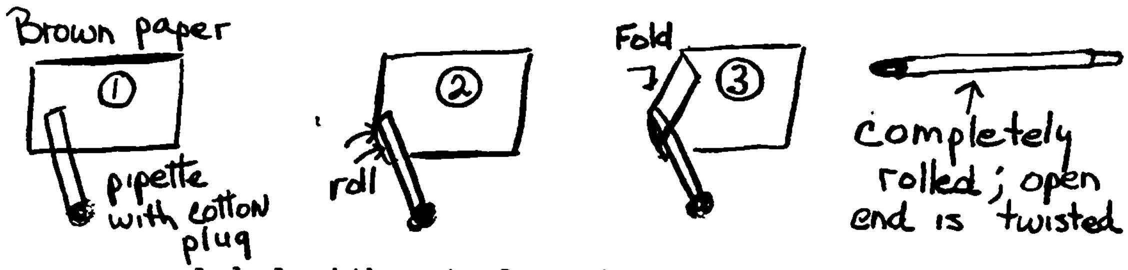
vii. fill the rest of the plates in this manner

viii. when the EMB has solidified turn the plates upside down and allow to stay over night (to dry the surface)

ix. for storage place in the refrigerator upside down

4. Preparation of 99 ml. Dilution Blank
   a. carefully measure 99 ml. of water and pour into a bottle
   b. set a rubber stopper lightly over the opening of the bottle
   c. label the bottle "99 ml. water" with masking or autoclave tape
   d. autoclave (refer to page 127 - Sterilization of Liquids)
   e. keep the stopper loose until the bottle cools, then secure it

5. Preparation of Sterilized Pipettes
   a. insert a <u>loose</u> cotton plug in the mouth of the pipette
   b. wrap the pipette by rolling it in brown paper or aluminum foil as shown:



   c. label with autoclave tape
   d. autoclave at 15 psi and 121°C (250°F) for 15 minutes

DIRECTIONS FOR COLLECTING WATER SAMPLES AND PERFORMING THE ANALYSIS

There are several things to remember in collecting water samples. Remember where you collect the samples, the time of year, and the temperature of the water. These are factors that can influence the amount of coliform bacteria present. A good place to take a sample is just downstream from the effluent pipe of the local water treatment plant. For comparative studies also take a sample upstream from the effluent pipe. (If you take two samples you need to make twice as much media and you will need twice the equipment.)

A. Procedure for Taking the Water Sample

1. Using the empty 250 ml. bottle (wide mouth) that has been sterilized, submerge it twelve to eighteen inches below the water; DO NOT REMOVE THE STOPPER UNTIL IT IS COMPLETELY SUBMERGED.
2. Remove the stopper being careful that your hand is behind the flow of water so no bacteria from your hand will enter the bottle (if you collect the sample from a boat <u>with a motor</u>, be sure you do not take the sample where gas or oil could get into the sample bottle.
3. While submerged stopper the bottle again.
4. <u>Keep the bottle stoppered</u> until you are ready to use.

B. The Initial Test

This test will tell you whether or not the water sample you took has coliform bacteria in it. Remember though, the bacteria may or may not be fecal coliform bacteria. A positive result could indicate those coliforms found in soil.

The initial test relies on the production of gas (carbon dioxide) by the bacteria. If there are any coliform bacteria present, then gas will be produced and it will begin to fill the inverted 6 mm. x 50 mm. tube (the tube may rise).

1. Equipment Needed for the Initial Test
   a. water sample
   b. 3 large test tubes with 10 ml. DSLB per tube with inverted 6 x 50 mm. tubes
   c. 9 large test tubes with 10 ml. SSLB per tube with inverted 6 x 50 mm. tubes
   d. 1 (10 ml.) pipette (sterile)
   e. 2 (1 ml.) pipettes (sterile)
   f. 1 bottle containing 99 ml. <u>sterile</u> water

g. bunsen burner
h. tray for dirty pipettes
i. incubator
j. labelling tape
k. pen
l. disinfectant and sponge (paper towel)

2. Procedure for the Initial Test
Always clean the table surface with disinfectant <u>before</u> and <u>after</u> use.

a. DAY I - collect the water sample in a sterile bottle (refer to procedure for collecting sample, page 132.
b. In the lab: in a test tube rack arrange 3 test tubes of double strength lactose broth and 9 test tubes of single strength lactose broth.
c. Procedure
   1. Label 3 DSLB test tubes 10 ml.-a, 10 ml.-b, 10 ml.-c (label on tape with pen).
   2. Label 3 SSLB test tubes 1 ml.-a, 1 ml.-b, 1 ml.-c (label on tape with pen).
   3. Label 3 SSLB test tubes 0.1 ml.-a, 0.1 ml.-b, 0.1 ml.-c (label on tape with pen).
   4. Label 3 SSLB test tubes 0.01 ml.-a, 0.01 ml.-b, 0.01 ml.-c.
   5. Label the test tube rack: period________
   6. Mix the sample bottle by shaking twenty-five times.
   7. Remove the cotton plug from a DSLB test tube [to remove the cotton plug hold the test tube in the left hand (if right handed) and with the "heel" of the right hand grasp the cotton, twist it, remove it; do not lay the cotton down, but keep it held in the heel of the right hand]; flame the lip of the tube; with a 10 ml. pipette transfer 10 ml. of sample water to the DSLB tube; flame the lip of the tube and replace the cotton plug; fill the remaining two tubes the same way; place the dirty pipette in a tray.

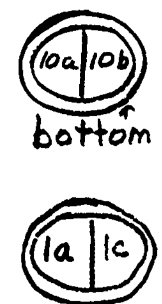
8. Following the same procedure but with a 1 ml. pipette transfer 1.0 ml. of the sample water to each of the 3 SSLB test tubes labelled 1.0 ml. DO NOT LAY THE PIPETTE DOWN.
9. Following the sampe procedure with the same pipette transfer 0.1 ml. of the sample water to each of the 3 SSLB test tubes labelled 0.1 ml. DO NOT LAY THE PIPETTE DOWN.
10. With the same 1 ml. pipette transfer 1 ml. of sample water to the 99-ml. dilution blank of sterile water; place the dirty pipette in a tray; shake the bottle twenty-five times.
11. With a sterilized 1 ml. pipette transfer 1 ml. of water from the bottle (99-ml. dilution blank) to each of the 3 SSLB test tubes labelled 0.01 ml.
12. Wash and store the equipment; always clean the table surface with disinfectant.
13. Incubate the test tubes at 35°C (98°F) for forty-eight hours.
14. After twnety-four hours and forty-eight hours, examine and record the number of test tubes in each set (10 ml., 1 ml., 0.1 ml., 0.01 ml.) that have at least 1/10 of the 6 x 50 mm. inverted tube filled with gas.
15. DAY III - Analyze and record the results (refer to page 136-Analysis of Initial Test Data).

C. The Confirmation Test
This test will confirm whether or not the positive results in the initial test were due to fecal coliform bacteria (E. coli).

1. Equipment Needed for the Confirmation Test
   a. the test tubes in the Initial Test that showed positive results (the ones that had gas production)
   b. one petri plate of EMB for every two tubes showing gas production
   c. inoculating loop(s)
   d. bunsen burner
   e. incubator

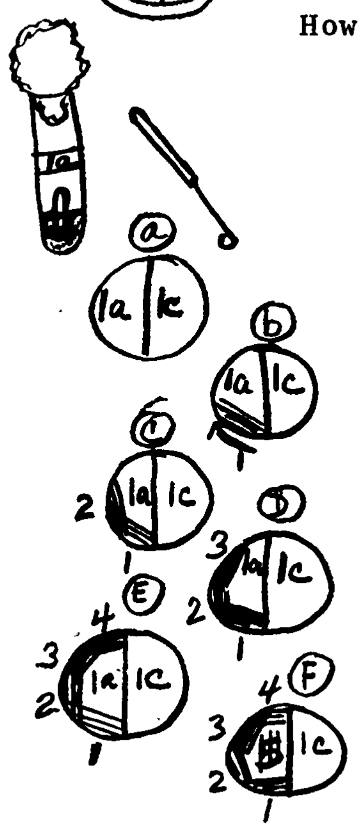
2. Procedure for the Confirmation Tests
Always clean the table surface with disinfectant before and after use.

Examples



a. DAY III - for each test tube with gas, label half the bottom of a petri dish containing EMB agar the same as the test tube.
b. DAY III - "streak-out" on half of a petri plate of EMB, 1 loopful of broth from each test tube with gas; "streak out" on the proper plate (refer to label on the bottom of the plate).

How to Streak Out



Agitate the tube gently to mix; remove the cotton plug and sterilize the lip of the test tube; also sterilize the inoculating loop before it enters the test tube each time.

Dip the loop into the broth and remove a loopful of broth; transfer this to the proper plate.

Streak the loopful of broth many times across the EMB plate in area 1.

Streak from area 1 across area 2 going back and forth, being careful not to cut the agar surface.

Streak from area 2 across area 3 many times.

Streak from area 3 across area 4 but do not touch area 1, 2, or 3.

Sterilize the inoculating loop; streak from area 4 across area 5.

c. Incubate the petri plates upside down for twenty-four hours at 95° to 105°F.
d. DAY IV - remove the plates from the incubator; open each plate one at a time and look for shiny metallic green colonies (these are colonies of Escherichia coli or fecal coliform bacteria).
e. DAY IV - analyze and record the results (refer to page 138 - Analysis of Confirmation Data).

Analysis of Initial Test Data

Introduction

The analysis of the data and computation of the number of fecal coliform bacteria present in the water are based on the fact that if 1/10 of the inverted tube is filled with gas, at least one coliform bacterium must have been present in the volume of sample introduced into the tube. Obviously, there may have been many more (hundreds, thousands, etc.) present, but this can not be assumed. Therefore, the exact number of bacteria present will not be known.* Thus, the calculation is expressed as the most probable number (MPN).

The number of bacteria per milliliter is the reciprocal of the smallest portion giving a positive result. For example, if the results were as follows.

10 ml. sample water	positive (1/10 tube filled with gas)
1.0 ml. sample water	positive
0.1 ml. sample water	negative

The MPN would be one bacterium per 1.0 ml. of sample water (1/1 ml. MPN), since the <u>smallest</u> amount of sample containing coliform bacteria was 1.0 ml. However, the MPN is always expressed per 100 ml. of sample water. Thus, the actual calculated result should read 100/100 ml. MPN. For example:

10 ml. sample water +
1.0 ml. sample water +
0.1 ml. sample water +
0.01 ml. sample water -

= 1000/100 ml. MPN

Results such as the following may appear because of the size of the bacteria and the chance involved in pipetting the water samples:

10 ml. sample water +
1.0 ml. sample water +
0.1 ml. sample water -
0.01 ml. sample water +

It stands to reason that if there is one bacterium in 0.01 ml. of the sample water then certainly there should be at least one bacterium in 0.1 ml. of sample water (however, this is

*The 10-fold dilutions prepared narrow the range.

not always so). This result should be computed as the reciprocal of the portion next larger than the smallest one giving a positive test (this being a more probable result). Thus, the MPN above would be 1000/100 ml. MPN.

Calculation

1. After twenty-four hours remove the test tube rack from the incubator, examine and record the number of test tubes in each set that have at least 1/10 of the 6 x 50 mm. inverted tube filled with gas.

2. Put a + in the box for each tube if there is at least 1/10 of the upside down (inverted) tube filled with gas; place the data in a chart similar to the following:

Test Tube (+ means gas production)

								per 100 ml.
10 ml. a	/+/	1 ml. a	/+/	0.1 ml. a	/-/	0.01 ml. a	/+/	1,000
10 ml. b	/+/	1 ml. b	/+/	0.1 ml. b	/-/	0.01 ml. b	/-/	100
10 ml. c	/+/	1 ml. c	/+/	0.1 ml. c	/+/	0.01 ml. c	/+/	10,000
							Total	11,100
							Average of 3 test tubes	3,700

For this sample of water (Initial Test) the MPN is 3,700 bacteria/100 ml. of the sample water; remember, these may not be fecal coliform and therefore may not indicate the presence of pathogenic fecal coliform.

3. Do not discard the data that has been recorded as it will be needed in analyzing the results from the Confirmation Test.

Analysis of Confirmation Test Data

Introduction

After the Confirmation Test has been run and the results have been recorded, a final result can be tabulated. If all the positive tubes from the Initial Test also produce the green colonies on the EMB, then the calculated MPN is confirmed, and all the tubes contain fecal coliforms and indicate the presence of sewage in the water. However, should some petri plates reveal that the bacteria present are NOT fecal coliform, the MPN must be adjusted as follows.

Test Tube (+ means gas production or green color)

					per 100 ml.	Adjusted
10 ml. a +	1 ml. a +	0.1 ml. a -	0.01 ml. a +		1,000	1,000
10 ml. b +	1 ml. b +	0.1 ml. b -	0.01 ml. b -		100	10
10 ml. c +	1 ml c +	0.1 ml. c +	0.01 ml. c +		10,000	1,000
				Total	11,100	2,010
Average 3,700			Adjusted Average			670

Suppose the two circled test tubes produced no green colonies on the petri plates. Simply adjust the results by changing the + (plus) to a - (minus) and re-calculate.

North Carolina Water Quality Standards
For Surface Water -- Coliform Content

CLASSIFICATION OF SURFACE WATERS

Class A-I Waters

usage: source of water supply for drinking, culinary, or food processing purposes
coliform content: organisms of the coliform group not to exceed 50/100 ml. MPN as a monthly average
fecal coliform: none

Class A-II Waters

usage: source of water supply for drinking, culinary, or food processing purposes with proper treatment
coliform content: not to exceed 5,000/100 ml. MPN as a monthly average; not to exceed 20,000/100 ml. MPN in more than 5% of such samples
fecal coliform: not to exceed a log mean of 100/100 ml. MPN based on at least 5 samples during a 30 day period nor exceed 20,000/100 ml. MPN in more than 20% of the samples in that period (not applicable during or immediately following rainfall)

Class B Waters

usage: bathing, water sports, fishing, etc.; not to be used for drinking water supply or for food processing purposes
fecal coliform: not to exceed log mean of 200/100 ml. MPN based on 5 samples in a 30 day period; nor to exceed 400/100 ml. MPN in more than 20% of the samples in that period (not applicable during or immediately following rainfall); applicable only during the months of May through September; during other months Class C water standards shall apply

Class C Waters

usage: fishing, boating, working, but not for bathing
fecal coliform: not to exceed 1,000/100 ml. MPN based on at least 5 samples in a 30 day period; nor exceed 2,000/100 ml. MPN in more than 20% of the samples during that period (not applicable during or immediately following rainfall)

Class D Waters

usage: agricultural, industrial, navigation, not for fishing, bathing, etc.
fecal coliform: not to exceed a log mean of 100/100 ml. MPN based on at least 5 samples in a 30 day period, nor 200/100 ml. MPN in more than 20% of the samples during that period

FROM: Rules, Regulations, Classifications and Water Quality Standards Applicable to the Surface Water of North Carolina, adopted by the Board of Water and Air Resources, Raleigh, North Carolina, 1970.

SUPPLEMENT #25

The Bacteriological Analysis of Water

Student Worksheet and Key

Directions: Answer the following questions as completely as possible. Use the scientific bibliography and any notes you may have taken.

Questions:

1. Why are we performing bacterial tests on the water samples?

   answer: to determine if human sewage is present in our water and consequently disease-causing bacteria

2. What are bacteria?

   answer: tiny plants made up of a single cell and visible only under a microscope

3. Why does water contain bacteria?

   answer: bacteria are very important because they feed on organic wastes breaking them down into simple chemical nutrients which can be used again

4. What are pathogenic bacteria?

   answer: bacteria that cause diseases

5. What problems may arise from pathogenic bacteria being present in our drinking water supplies?

   answer: anyone drinking water with these bacteria present may become infected and such diseases as typhoid fever, cholera, and dysentery may result

6. Why can't scientists test water samples for pathogenic bacteria?

   answer: these bacteria are hard to detect because they do not grow well outside the human body; besides, it would be impossible to test all sewage for bacteria

Supplement #25 (Cont.)

7. What do scientists test water samples for in terms of bacteria?

   answer: the water is tested for the presence of non-pathogenic bacteria which are normally present in the human intestines ("coliform bacteria")

8. What special substance does coliform bacteria feed on?

   answer: lactose

9. What two tests must be performed to find out if "coliform bacteria" are present in a water sample?

   answer: The Initial Test (to check for gas production); The Confirmation Test (to determine if the bacteria are fecal coliform)

10. What does it mean if coliform bacteria are present?

    answer: if coliform bacteria (non-pathogenic) are present, there may also be pathogenic bacteria present

INTRODUCTION TO UNIT IV

As previously indicated, your emphasis for this course may be on unit III or IV, unless you extend the course beyond the 12-week schedule. We have taught the course (in 12 weeks) emphasizing either unit III or IV and achieved positive student results either way. If unit IV is to be emphasized it is important to understand:

1. The decision to tackle a local problem will probably result in an overwhelming degree of student involvement and (often naive) excitement. The students will probably decide on many activities they want to do (like conducting surveys, raising money, preparing and distributing leaflets) and your schedule will need to be very flexible. Therefore, consider the ideas offered in this unit as a guide, using only what you think is applicable to your situation, and in any sequence that seems appropriate.

2. If you are a science teacher, you probably do not know very much about local politics, economics, and sociology. But every town contains many individuals who would be willing to come to your class to answer questions and offer ideas. Some examples are: mayor, city manager, member of the city council, county commissioner, planning board member, member of the chamber of commerce, city director of public works, city planner, members of civic organizations, water plant operator, personnel from local industries, attorneys, and partricularly those individuals employed by state and federal governments.

3. Admit from the start that the problem may not be solved by the end of the course. The single most important reason for trying to solve the problem is to teach them the <u>skills</u>. Once they have learned the techniques for solving environmental problems, they will have the rest of their lives to be an environmental activist. Comments like this will help reduce the frustration that develops when their plans become blocked by the usual obstacles: money and people.

4. Do <u>not</u> divide the class into committees, each tackling a different aspect of the problem unless you're sure the students can make decisions without a lot of supervision. You can't possibly divide your time among several committees effectively. Brain-storming groups may work and then meet as a whole class to present ideas Groups can also be used to work on predetermined projects (making a booth, writing a leaflet, drawing a poster). A good rule is to use groups only when you feel the groups can function effectively with a minimum of your personal attention.

5. Try to get <u>out</u> of the classroom and <u>to</u> the physical location of the problem(s) as much as possible. Class time can be spent <u>at</u> the city administrative offices, <u>at</u> the water plant, <u>at</u> the source of the problem, <u>at</u> the shopping center where the target population can be addressed in person. A <u>suggestion</u> is to obtain your chauffeur's license and arrange for a school bus to be parked at your school for rapid transit during a single class period. This may seem extreme, but we have done this (admittedly with some initial misgivings!) successfully.

6. If you are teaching several classes, it may be easier for you to let them all work on the same problem. And don't overwork <u>yourself</u>. Let the students type their own stencils, provide much of their own materials (e.g. paints, paint brushes), and even contact many of the resource people (but be certain the students are coached on what to say).

7 Don't feel pushed to do everything. Try to maintain a "relaxed excitement", in the classroom. You may not (probably won't) solve the problem: remind the students that they're being trained as activists. Encourage them when they become disillusioned but don't become a starry-eyed Pollyanna! Don't deceive them into thinking there is an "enemy" who is all bad and they all good. Try to instill a realistic attitude without being a defeatist. Help them to understand both sides.

8. When you anticipate the end of the course drawing near, leave time for reflection and evaluation. Review what you've accomplished and discuss your effectiveness, possible improvements in tactics (for the next time!) and what each individual has learned.

9. We have discovered a closeness, an empathy, with not only our students, but with the nature of the environmental situation by using the approach described above. The suggestions are the result of much trial and more error and we recommend them with confidence!

Good Luck!

UNIT IV SCHEDULE

TO THE TEACHER

This unit is least specific as to format because it is a very flexible unit and the emphasis placed on it is predetermined by Unit III. Consequently, this unit is given in three parts with suggested activities for each part. No exact schedule is given but a minumum of 10 periods to a maximum of 30 periods could be spent on the unit.

Part A	Local Study - Sociological	6 - 10 periods
Part B	Local Study - Economical	3 - 8 periods
Part C	Local Study - Political	7 - 12 periods

Depending upon the class and the kind of project adopted, Parts A, B, and C may not be covered as separate units, but interwoven as the project plans and activities develop naturally.

Perhaps the most vital responsibility the teacher has is to remain optimistic and positive about the effectiveness of environmental action, without being unrealistic. Students must learn that environmental actions succeeds slowly and only after a lot of committed participation on their part, but that it can succeed. The students will often be frustrated by economic problems and narrow-minded officials and your most important function will be to temper patience (theirs) and practicality with hope and enthusiasm.

UNIT IV PLAN

UNIT IV TITLE: A LOCAL STUDY OF WATER QUALITY

TIME: 10 to 30 periods

PURPOSE OR OBJECTIVE

For students to initiate the formation of a plan for solving a local water quality problem.

For students to learn that solving environmental problems involves an understanding of and rational study and resolution of not only the scientific facts, but also the economic, political, and sociological factors that impinge on the problem.

For students to learn that solving environmental problems requires intensive and careful planning and wholehearted commitment.

ABSTRACT

Based upon the advice of authorities and the results of the students' water studies and information gained from local authorities a plan for solving a local water problem is initiated to attempt to solve a target problem.

SUPPLEMENTS

UNIT IV: A LOCAL STUDY OF WATER QUALITY

Part A Plans

Local Study - Sociological

TIME: 6 - 10 periods

ABSTRACT

Based upon student-devised polls, the local populace is evaluated in terms of interest groups and awareness of local water pollution problems as well as willingness to help solve these problems. The students' project proposal is refined to appeal to (or at least not alienate) as many interest groups as possible, especially the most powerful groups.

UNIT IV: A LOCAL STUDY OF WATER QUALITY

Activity Plans (Part A)

A Survey of the Local Populace

TIME: 6 - 10 periods

SUGGESTED ACTIVITIES

Activity #1 - Preparing A Survey

A. Students should be made aware of the need for appealing to the local populace for support of their proposal. The concept of interest groups and city leaders should be discussed and students led to realize that their proposal will be most likely accepted if it appeals to the greatest number of (or the most powerful) interest groups. However, principle and reality need not be sacrificed just to make the proposal attractive to an influential interest group or make the proposal non-controversial.

B. Having been made aware of the need for appealing to local groups for support of their proposal students should first attempt to locate any reference people they might need. The students can accomplish this by being taught how to use a phone book to find the necessary reference people (refer to supplement #27, Let Your Fingers Do the Walking). Request the students to bring in a phone book as this will make it easier to complete the exercise. Also you may be able to borrow some phone books from your local phone company. During class discuss simple mechanics. Assign what is not completed as homework.

C. To channel students into the next phase (the planning and implementing of the project) perhaps a professional planner or city manager could be consulted to hear the proposed project and suggest the appropriate chronological steps in implementing the plans. It is probably best to let the students contact these resource people, but make sure the students know how to ask and what to ask!

D. When the students have decided on the appropriate steps, they can begin to solve the target problem. A suggested resource person at this time might be an engineer who could listen to their plans, add to, or modify these and offer technical advice.

E. Probably the next step for the students would be to sample public opinion to find the interest groups /those affected by the project, those which would benefit from the project, environmental action groups, and influential (or powerful) interest groups/. The mechanism for determining what the interest groups are is through the use of a poll. The students should formulate a questionnaire that is easy to score and evaluate (stick to yes or no; agree or disagree). Working as a unit have the students list on the board what they want to find out from the local populace. Condense their questions to simple terms. Distribute a copy of the questionnaire to each student. Assign each student a certain number of homes and businesses to visit in his neighborhood. On a local map keep a record of the areas polled so as to prevent repetition (refer to supplement #28, A Sample Survey Questionnaire). If the results from the questionnaire do not come in quickly, a visit to the library (school and public could be useful). Refer to supplement #29.

Administering the Survey

The students should be given from one to three nights to collect data from their neighborhoods. Coach them in asking the questions and introducing themselves. Review with the students how to fill in their chart. Encourage them to collect their data as quickly as possible. During this period, class time may be spent visiting the library as mentioned in E above.

Evaluating the Survey

On the board place the following charts:

SEX / QUESTION NO.	MALE	FEMALE	TOTALS
1			
2			
3			
4			
5			
6			
7			

**

AGE GROUP QUESTION NO.	AGE GROUP 1	2	3	4	5
1					
2					
3					
4					
5					
6					
7					

**

OCCUPATION QUESTION NO.	1	2	3	4	5	6	7	8	9
1									
2									
3									
4									
5									
6									
7									

These charts can be given to the students. Instruct the students to record their data in the appropriate chart. It might be easier if one chart is done at a time with the students working as a group (walk around and help the students). Collect the data at the end of the period. The following day prior to class, total the students' data and place on the charts on the board. In class go over the data one question at a time. At this time, also have the students list on the board all the interest groups they have in their survey (housewives, merchants, industrialists, etc.). Add any interests they didn't poll but know exist.

* refer to supplement #23

**NOTE: the charts above are suggested examples. Do not tabulate results by sex (or age, or occupation) unless you are interested in these. You may want to compare neighborhoods instead.

SUGGESTED ACTIVITIES (Cont.)

Activity #2 - Interest Groups

Students role-play to anticipate the reaction of the various interest groups to their proposal. Divide students into groups of four each (try to get variety within each group as to sex, interests, etc.). Interest groups (one or more) are assigned to each group until all interest groups are covered. Have one group (or student) voice the class proposal as it has been planned, including all details decided upon at this time. Give the groups several minutes to agree on a response (supportive, argumentative, negative, critical). A spokesman from each group can then present their response (keep a record on the board summarizing their stand). Rotate from one group to the next, until all interest groups respond. Do this quickly! Don't get "bogged" down and waste time! The proposal - presenter group should debate interest groups to try to bring them around to their viewpoint. <u>Debate</u> is not synonymous with <u>argue</u>! (Refer to supplement #30 for additional information about the role-playing).

Activity #3 - Evaluating and Organizing

Having role-played, the students should have some knowledge of which interest group (those present in their city) would be sympathetic or not sympathetic to their proposed project. During a class period have the students organize the interest groups according to those sympathetic and non-sympathetic and give reasons for their grouping. Review the reasons given for grouping the various interest groups and modify or amend the project proposal to satisfy those groups the class agrees would be beneficial as supporters. Table this information to be used later.

STENCIL

SUPPLEMENT # 2o

Who cares ?!

It's not my problem

It costs too much

The Psychology of ENVIRONMENTAL QUALITY CONTROL

We're all goneadie ?!

Help

DON'T JUST Complain ABOUT WATER POLLUTION. . . . . . .

DO SOMETHING!

Well, you wouldn't be in this class if you weren't concerned. So what? What's the good of being concerned? Any ne c... complain. . .but not many people are willing to

WORK

O.K. even, if you're still reading, I know you're more than just a complainer. So let's get down to the frustrating, difficult, expensive, and rewarding task of real environmental quality control! Let's become an "environmental activist".

LET'S DO SOMETHING!

This paper will deal with the first problem you'll confront: people; and what you'll need to know to deal with people. psychology.

We'll call this phase of our project: sociology (since we'll be dealing with people).

FIRST: You must decide what 'ills' you want to cure. So write in below your

1. Individual project:

2. Class project:

SECOND: take the time to do the job right. IN OTHER WORDS, PLAN! Write your plan (for your individual project only), that is what are you doing (stepwise plan).

List reasons why you are doing this project:

Supplement #26 (Cont.)

THIRD: Now read over your reasons and ask yourself this question: would my reasons really convince anyone my project is worthwhile? If your answer is 'no' think again about the reasons why you are doing the project and come up with some really convincing reasons. Now rewrite your reasons if you have to because. . .if you can't think of any good reasons - why do it?

NOW FOR THE PSYCHOLOGY

Environmentalists have a really rough job for a very good reason: People are selfish, lazy, money-conscious, and afraid to face unpleasant responsibilities.

You yourself have already faced your first responsibility (unpleasant for some) as an environmental activist. You studied the facts about water pollution. That was easy because you only had to work with 2 people: yourself and your instructor.

And now your second responsibility is to select a problem and seek to eliminate it. To do this you should first find out how aware the community is of this problem and how far they'll go to help solve it. You can't talk to everyone, so you'll have to "sample" the population. That is question a large number and assume those you question are typical of most people in your community.

Sociology

AFTER you find out how much people know and how much they'll help, you're ready to plan your strategy:

BECAUSE

If the folks don't know there is any problem, how can they help?	If they don't know what causes the problem, how can they help?	If they don't think the problem hurts them, THEY WON'T HELP.

STRATEGY

PUBLICIZE THE PROBLEM - radio, news, posters, etc.	EDUCATE THEM - radio door-to-door, newspaper, posters, etc.	APPROACH the public like you do your parents when you want their consent!

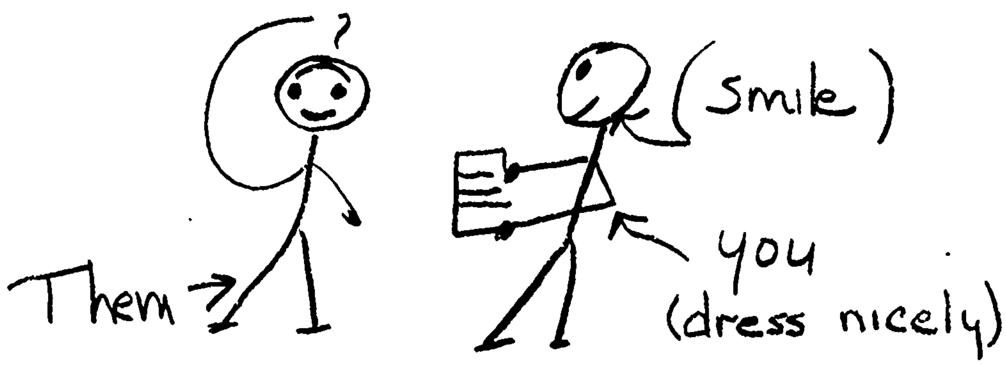
Supplement #26 (Cont.)

Talk about your project to people in the most certain way to win their support. Tell them how your project will help or benefit THEM. That's all most people really care about. So if you really want their approval, you'll have to convince them that you in turn, are helping THEM.

BY THE WAY

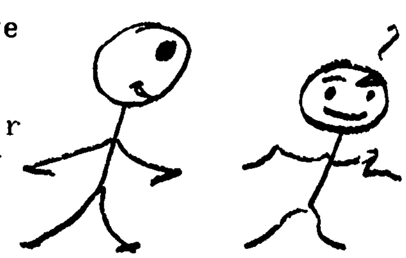
When you interview townspeople, keep in mind these pointers!

1. Be polite.
2. Introduce yourself.
3. Ask them if they have the time to answer your questions.
4. Explain why you need their answer.
5. Don't act superior.
6. Thank them for their time and answers.



IF/PEOPLE/LIKE/YOU,/ THEY WILL WANT TO HELP YOU.

People don't like to be forced, or talked down to or made to appear dumb.



People do like to feel important. To feel what they have to say is important and to see that you're serious and SINCERE!

After you complete your survey or opinion poll, you should study your results very carefully. For example do you need to change your plans for your project or your reasons for your project to make it more appealing? Have you found out who in the community will be helpful? If so, make a list of these people and include them in your plans.

Supplement #26 (Cont.)

For example, your personal project may need help. So list below the people or kind of people who can help you:

Is your list short? Do you need some help? If you do, think about how you can make your project seem important to more people. . .even if it means giving up a part of the project that many people are very much against, or changing the project a little to make it more appealing. BUT DON'T GIVE UP MORE THAN YOU REALLY WANT TO--DON'T CHANGE MORE THAN YOU REALLY WANT TO JUST TO MAKE MORE PEOPLE HAPPY. IT'S YOUR PROJECT-EVEN IF IT MEANS MORE WORK OR MORE AGGRAVATION, DO IT THE WAY <u>YOU</u> WANT TO.

When you know the people in town, how they feel, what they know, how they'll help, how they think THEN PUBLICIZE AS MUCH AS POSSIBLE. Hit the people constantly with how important your project is to THEM. And let them know how <u>they</u> can help!

TO SUMMARIZE

Find out who will be affected by your project and whose help you need.

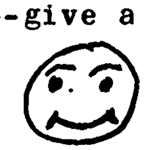
Talk to those people (make a survey) to find out how much they know about the problem and if they would help.

Try to win their support by nicely and politely publicizing your project.

Be optimistic--don't just make people concerned--tell them what they can do to help.

Show the people how the project affects THEM personally.

To win people over, compromise--give a little,

smile a lot  and

let people know you're sincere.

Supplement #26 (Cont.)

Make people believe you are concerned about <u>them</u> (not just the fish and the birds).

Be informed. If you act and talk in ignorance, people won't trust or believe in you. Therefore, they won't want to help you.

Finally,
(I'll share a secret with you)
Sshh. . .

(Seek POWER)!

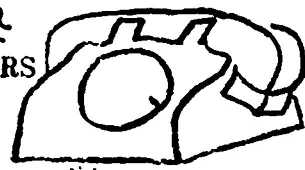
Find the important people in the community that can help with the project AND WIN THEM OVER. Remember: these powerful, influential people are usually very well informed. Be sure you KNOW what you're talking about before you contact them. Don't make a fool of yourself!

List here those people in the community who have either official or social power and could give you advice or other help for your individual project:

AND DON'T FORGET TO GET THE HELP OF CIVIC GROUPS AND CLUBS. Make a list of civic groups and clubs in your town you could contact. For more information, contact the Chamber of Commerce.

If you follow these pointers you will be doing the very best service you could do for the "Environmental Cause". You know, many people hate environmentalists because of the way many environmentalists act. So let's change that image. . .NOW!

SUPPLEMENT #27

(sociology)
LET YOUR FINGERS  DO THE WALKING

If you want to clean up the environment - and KEEP it clean

You're going to need a lot of help!

There are officials representing local, state, and U. S. government that are available to help, but you have to know how to FIND them. And there are many <u>un</u>official, but important people who can help---<u>IF</u> you know where to find them.

And since organizations and officials change over the years, what you need to learn is **NOT** names, but **HOW TO FIND THE HELP YOU NEED WHENEVER YOU NEED IT.**

THEREFORE:

> find out who you'd contact TODAY concerning the following issues, and record how you found these individuals. This can serve as a guide for the rest of your life!

ISSUE	CONTACT	EXPLAIN HOW YOU FOUND THE CONTACT
1. Who protects waterways from litter?		
2. Who can tell you the LOCAL laws that protect our waterways?		

Getting frustrated? Here's a hint: look under these main headings - the name of the city, of the county, of the state, and under U. S. Read the names of the offices listed and see if any "sound" right. To be <u>sure</u>, we can assign each issue to a different student and <u>let</u> him call when he gets home and ask the agency if they are the right one. Feel better?! Now try to figure out no. 3 - 12.

ISSUE	CONTACT	EXPLAIN HOW YOU FOUND THE CONTACT
3. Who can tell you the STATE laws that protect our waterways?		
4. Who can tell you the FEDERAL laws that protect our waterways?		
5. Who sees that local ground water is not polluted?		
6. Who sees that local rivers and creeks (surface waters) are not being polluted?		
7. Who tests water to see if it's polluted?		
8. Who ENFORCES the legal water quality standards (that is, who makes sure waters are not being polluted and makes the arrests)?		
9. Who checks septic tanks to see if they are working properly?		
10. Who could you talk to about city garbage, water and sewage treatment?		
11. Who would you report a fish kill to?		
12. Who would you contact to get publicity and help on a pollution problem?		

SUPPLEMENT #28

A Sample Survey Questionnaire

Introduction

Hello, I am ________________ in Mrs. __________ Environmental Science Class. We're taking a survey concerning (class project: ex.: the use of septic tanks. Would you have the time to answer a few questions? Has anyone interviewed you before about (ex.: septic tanks)?

Person Interviewed	Sex M/F	Age Group 15-20	21-29	30-39	40-59	60-up	*Occupation	*Industry you work for
1								
2								
3								
4								
5								

*attached sheet

Specific Questions:

Person Interviewed	Question: Do you have a septic tank? Yes	No
1		
2		
3		
4		
5		

Supplement #28 (Cont.)

Question: Would you rather have a city sewerline?

	Yes	No
1		
2		
3		
4		
5		

Question: If they don't want a city sewerline, ask why they don't.

too costly	septic tanks better	too much trouble	no good reason for changing
1			
2			
3			
4			
5			

*Occupation

(1) professional and technicians
ex.: engineers, doctors, lawyers, city planners, teachers, medical and dental technicians

(2) executives
ex.: owners, managers of businesses and other enterprises; proprietors of wholesale and retail establishments

(3) clericals
ex.: office workers (bookkeepers, cashiers, secretaries, stenographers, typists, filing clerks, corporate manager)

(4) sales
ex.: clerks in stores and other selling jobs such as insurance agents

(5) craftsmen (jobs that require skills that can only be learned over a period of years)
ex.: carpenters, plumbers, electricians, T.V. repairmen; also all work supervisors (foreman)

Supplement #28 (Cont.)

(6) operators (people whose job requires little or no training and the use of simple tools)
ex.: ditch diggers, men who lay railroad ties

(7) service workers (people who perform services for others)
ex.: gas station attendants, maids, cooks, barbers, waiters, hotel workers, cleaners

(8) housewife

(9) unemployed

*Industries

(1) communications
ex.: telephone, telegraph, radio, T.V. broadcasting

(2) manufacturing - producing
ex.: furniture, machinery, electrical supplies, food and tobacco products, clothing, transportation equipment, books

(3) service
ex.: hotels, laundries, motion pictures, medical services, hospitals, schools, advertising,

(4) construction

(5) trade
ex.: wholesale and retail; selling food, furniture, clothes, and including restaurants

(6) finance
ex.: insurance, real estate, banking

(7) transportation
ex.: includes utilities (gas, electric, sanitary service), railroad freight

STENCIL

SUPPLEMENT #29

The Library

The Library can help you solve environmental problems (if you know how to use it!) HOW can the library help?

Let's take general questions you would ask if you were concerned about solving local environmental problems. Try to list books available in the library that can answer these questions for you.

QUESTIONS	REFERENCES IN THE LIBRARY
1. Does an environmental problem exist in our area? What kind of plans does the city have for expansion and industrial growth? What factories are in our town?	
2. What are the laws that protect our environment? Who enforces the laws?	
3. How much does the city spend for environmental protection and improvement? What is the city budget? Can the city afford to pay the cost of environmental protection? Does the city, state, and federal government have money to spend on environmental protection and improvement?	
4. How would I go about solving an environmental problem? What government officials would I need to talk to?	

(Other Questions)

SUPPLEMENT #30

Role - Playing

Instructions

Before class prepare cards with the following environmental issues on them:

Proposal #1 - treat storm water at the city sewage treatment plant to remove pollutants
plan: use large holding ponds to receive the storm water; skim off oils, let solids settle, run through a digester and trickling filter

interest groups - environmentalists, city council, recreation seekers (fishermen, hunters, swimmers), personnel of city sewage treatment plant, taxpaying citizens, engineering firm (performs surveys, cost estimates, makes blueprints, lays pipes, builds treatment facilities), Department of Natural and Economic Resources, Water Pollution Control Division, State Department of Public Health

Proposal #2 - eliminate the use of septic tanks
plan I: annex subdivisions into the city
plan II: form sanitary district or water and sewer authority

interest groups - environmentalists, property owners in subdivisions; sellers, installers, repairers, cleaners of septic tanks; city council, Department of Natural and Economic Resources, State Department of Public Health

Proposal #3 - upgrade the water quality of a creek for the purpose of getting its classification changed from "D" to "B"
plan: eliminate the following sources of pollution: city run-off, farm erosion and run-off, construction site erosion, boat pollution, animal wastes from pets and farm animals

Supplement #30 (Cont.)

interest groups - environmentalists, farmers, property owners along the creek, Department of Natural and Economic Resources, private construction and bulldozing companies, marina owners, and boat owners, property owners in city, pet owners

Rules

One group of students pick a proposal (sight unseen). This group becomes the Department of Natural and Economic Resources. This group reads the proposal to the class. Then they stack the interest group cards for the proposal and let each of the remaining groups draw from the stack until all the cards are gone. While the Department of Natural and Economic Resources write their complete plan for the proposal and prepare their arguments, all the groups prepare their arguments (reasons) in writing either for or against the proposal. Allow approximately five minutes for this process.

The Department of Natural and Economic Resources then calls a public hearing at which the proposal and plan is read. Each interest group gets to read their arguments and discuss these in the meeting. The class votes on the proposal after all presentations and discussions. Each student votes as a member of his particular interest group. Each member gets one vote. The Department of Natural and Economic Resources counts the votes and reads the decision.

The presentation and discussion of each proposal takes approximately 35 minutes. The teacher can score the students based on how valid their arguments are.

SUPPLEMENT #31

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UNIT IV: A LOCAL STUDY OF WATER QUALITY

Part B Plans

Local Study - Economical

TIME: 5 - 8 periods

ABSTRACT

The students will learn how to investigate the financial resources available within a city for funding a community project. Having investigated these financial avenues, the students will write a budget for their project finding as many potential financial backers as possible, and if necessary adjust the initial budget to a feasible cost.

UNIT IV: A LOCAL STUDY OF WATER QUALITY

Activity Plans (Part B)

Preparing a Budget

TIME: 5 - 8 periods

SUGGESTED ACTIVITIES

Activity #1 - Recognition of Financial Backers for the Project
Work with the students to divide the proposal into items that must be paid for. For example, improved sewage treatment facilities would include laying more sewage lines, constructing a new building, hiring personnel to run the plant, connecting residents to the new lines, and others. Also have the students decide who could help them prepare their budget

If possible, invite an authority to class to be sure all necessary items are accounted for (for example a sanitary engineer would be an excellent resource authority). If the authority can't help estimate costs, point out to students that this situation is typical because of the many variables involved in this problem. Provide each student with a copy of the proposed budget.

Activity #2 - Researching Available Funds for Financing the Project
Obtain a copy of the city budget. Have the students study this to determine how much money is available that could be used for the project. Question a city father (councilman, mayor, etc.) to investigate all possible avenues for supplementing the budgeted amount: bonds, taxes, etc. Also obtain information from the local health department, Environmental Protection Agency, and Department of Natural and Economic Resources (offices should be nearby) on what state and federal money is available and how to apply for it. Request the students to prepare an organized list of all available money.

Activity #3 - Revising the Budget
The students should revise their budget so that it doesn't total any more than there is potential funding for it. Try to get the students to be realistic relating to possible levying of taxes.

SUPPLEMENT #2

The Economics of Water Quality Control

SO YOU'VE NOTICED WE FACE A HUGE OBSTACLE TO SOLVING OUR ENVIRONMENTAL PROBLEMS?

And it's a tough one . . . I don't even have to tell you what it is. . . .

You now have the scientific know-how.
You understand the psychology of facing a world full of selfish, lazy people.
You know how to find people who can help you make good plans for solving environmental problems;

BUT
YOU DON'T HAVE THE MONEY
(and you can't solve environmental problems WITHOUT IT!)

DON'T DESPAIR! It's not hopeless. I think I can help you win at least some points when you argue--excuse me!--discuss--environmental plans with the money-conscious public and politicians.

LET'S GO BACK to the psychology. That's, after all, what it's all about. You won't win as much environmental improvement on sound logic as you will win on appealing to INNER EMOTIONS and using the "RIGHT APPROACH". What's the right approach?

IT'S SO SIMPLE

First, when you are trying to convince someone we should spend the money on a project that will improve environmental quality, don't be "pushy". Do it so:

1. Ask enough questions to find out how the other person really feels (he may agree with you). It will make him feel important--he'll like you for that.
2. Don't argue yet. Don't let him know your real thoughts - yet.
3. Accept his ideas without showing anger or dislike. Build his confidence. He'll like you more and that's important. He'll begin to respect you.
4. NOW - very quietly and patiently begin to suggest your own ideas. If they disagree with his, never call him stupid or in any way imply that he's all wrong.
5. Always nod and smile at his comments, but more and more offer your own ideas and try to get him to see your side.

Supplement #32 (Cont.)

AND WHAT IS YOUR SIDE?

There are plenty of things you can tell him. Here are some examples:

1. The benefits of a clean [illegible] cannot be measured in dollars and cents.
   A. How much is your [illegible] worth to you? Pollution causes sicknes[illegible] even death. Pesticides and other poisons get in our food and water, air pollution gets in our lungs, germs get in our water from run-off and sewage.
   B. How much is the sight of [illegible] [illegible]iful river or forest worth? Or the pleasures [illegible]ng able to find a river clean enough to swi[illegible] fish in? Pollutants kill wildlife; land abuse destroys forests and waterways.
   C. How can we morally spoil an environment we must leave for generations yet to come? We need to leave them a world uncontaminated.

2. Pollution damages health, plants, and property.
   A. Air pollution alone costs the U. S. ($16,000,000,000!) 16 Billion Dollars EACH YEAR in damage to human health, plants, and property values. (reference - The President's Council on Environmental Quality)
   B. Air and water pollution together cost the nation almost ($29,000,000,000) 29 Billion Dollars each year. (reference - National Wildlife Federation)

MORE ARGUMENTS YOU CAN USE TO JUSTIFY SPENDING THE TAXPAYERS' MONEY TO IMPROVE THE ENVIRONMENT:

3. The Wildlife Federation study says that if we begin [illegible] pay the cost of clean-up NOW, by 1979, we would save enough money to pay off our past costs of the clean-up;

   AND BY 1980 WE WOULD ACTUALLY BE SAVING MONEY.

4. People who lose jobs (scientists and technicians) because of factory cut-backs and shut-downs in an effort to reduce pollution can get Labor Department money for job-hunting travel and moving costs.

5. A city doesn't have to raise taxes to obtain money for projects. Bonds could be sold.

6. Even if taxes are raised to pay the cost of clean-up or to prevent future pollution this is still cheaper than waiting for the situation to get worse and cost more. Prices go up more and more every year.

Supplement #32 (Cont.)

7. The U. S. Government is beginning to help pay the costs of environmental improvements. Here is a list of departments and agencies to write to for money. (For more information, see local Economic Development Commission.)

Department of Agriculture:
- Farmer's Home Administrations (FHA)
- Soil Conservation Service (SCS)

Department of Commerce:
- Economic Development Administration

Department of Defense:
- Department of the Army, Office of the Chief of Engineers

Department of Health, Education, and Welfare (HEW)
National Institute of Health
Office of Education
Department of Housing and Urban Development (HUD)
Department of Interior:
- Bureau of Outdoor Recreation
- Bureau of Reclamation
- National Park Service

Department of Justice:
- Law Enforcement Assistance Administration

Department of Labor:
- Manpower Administration

Department of Transportation:
- Federal Highway Administration
- Urban Mass Transportation Administration

National Science Foundation
Office of Economic Opportunity
Water Resource Council
Environmental Protection Agency:
- Air Pollution Control Office
- Solid Waste Management Office
- Water Quality Office

AND THOSE ARE JUST THE FEDERAL SOURCES OF FINANCIAL ASSISTANCE!

SUPPLEMENT #35

Bibliography - Economic

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UNIT IV: A LOCAL STUDY OF WATER QUALITY

Part C Plans

Local Study - Political

TIME: 7 - 12 periods

ABSTRACT

Based upon a variety of activities the students will determine the local government's power structure and the unofficial local power structure; become knowledgeable of local, state, and national environmental protection officers and their functions; become knowledgeable and skilled in gaining support of local interest groups, and how to present a community improvement project to various individuals and groups.

After the students have determined the best channels for presenting their water quality study and project proposal, they complete the course by officially presenting the proposal as planned.

Evaluation of the proposal, based upon the responses of the listeners, and reworking of the proposal (if needed and time) conclude this unit.

UNIT IV: A LOCAL STUDY OF WATER QUALITY

Activity Plans (Part C)

Determining Local Power Structure

TIME: 7 - 12 periods

SUGGESTED ACTIVITIES (refer to supplements #33, #34, #35, #36)

Activity #1 - How and to Whom to Present the Proposal To (approximate time 2-4 periods)
To determine how and to whom to present the proposal, divide the section into the following four parts: (a) who officially controls water quality; (b) who governs the city; (c) who influences city government unofficially; (d) who "owns" the city (financially). In each part the students compose a power structure chart. The charts for each section are given below.

Chart A. Water quality control - use a phone book and references to list all official environmental agencies; record the information in the chart; circle those the proposal will need to be presented to (either in writing or orally)

Legislative (lawmakers)	Executive (enforcers)	Advisory

Chart B. Who governs - students decide what the official governmental bodies are (phone book should help); the students should draw and label their power structure; an example of a power structure is given below (this represents a democratic structure).

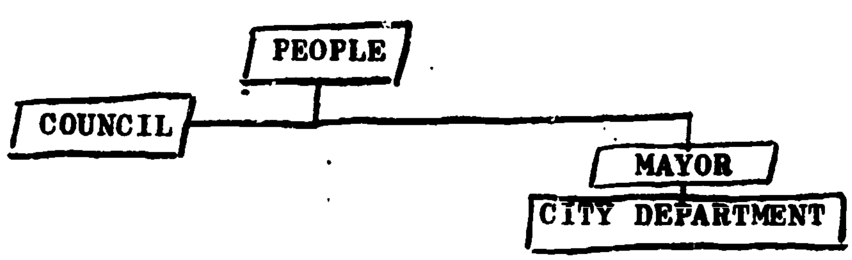

Chart C. Who influences - students decide how local politics really work including this time all the "unofficial" influences; if time permits review past, major city decisions via newspapers to see who has previously been influential; students should be reminded that pressure groups change depending upon who is most affected by the proposal (refer back to interest groups); the students should draw and label another power structure; an example of such is given below.

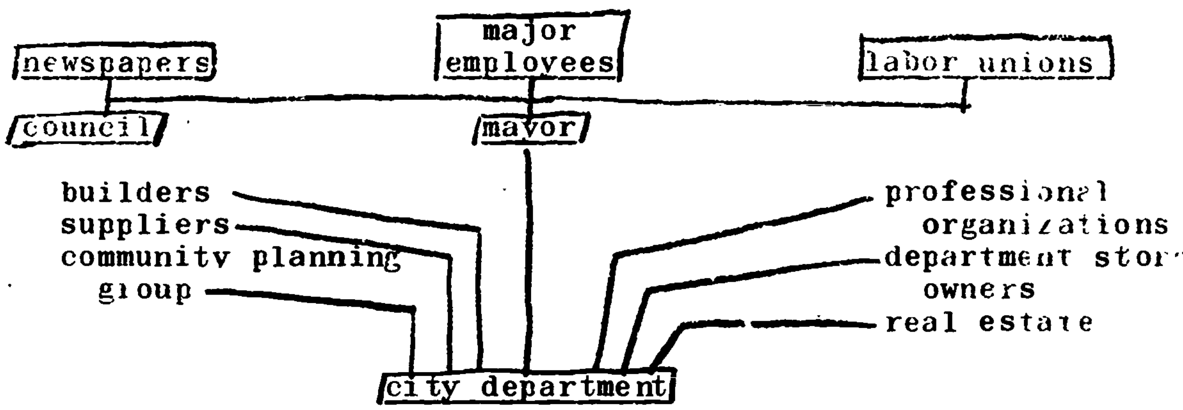

Chart D. Who represents power in the city - ask students who they think would be most likely to wield power or be a strong influence in city decisions (that is, what <u>kind</u> of people influence city decisions); probably the students will decide that those who own the most property or make the most money would be the most influential; refer to charts to determine what group(s) "own(s)" the city and make a list.

Additional information and possible activities which might be useful at this point are supplements #33, #34, #35, and #36.

Activity #2 - Presentation of Students' Research Proposal (approximately 3 periods)
The students should decide what individuals and organizations need to hear their proposal. Referring to the charts a scheme for presenting the proposal should be outlined. This might include writing news articles and perhaps even inviting some people to class. Next the students should individually (or in small groups) decide who they wish to present the proposal to. The presentations should be divided in an effective but practical way.

For example, those students who could go downtown after school could visit the city departments and a student who lives in a rural area could write news articles or draw posters to gain public support. Another possibility would be for a group of students to prepare a simple leaflet for distribution including such information as (1) facts and figures that justify the need for the project; (2) findings and conclusions; (3) what the public could do to help. Taping the presentations and responses would be helpful, especially in the evaluation.

Activity #3 - aluation

Note: Since this is the last unit, time should be allotted for evaluation (by discussion) of the course and suggestions for improvement.

An evaluation of the effect of, and response to the students' presentations can be effected by the students relating their experiences, followed by a class discussion. If time permits, the students may want to rework their proposal based upon criticisms and overall responses received during the presentations. Whether or not the students' proposal is implemented may hinge on many controllable and uncontrollable variables (it would be good to discuss this in class). Also point out and discuss the fact that many community projects never are implemented (try to get this across without destroying the students' confidence or faith in citizen action).

SUPPLEMENT #34

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THE SALT IN OUR BLOOD 321796
should government regulate what's put into the seas

ECOLOGICAL POLITICS #22079

SUING FOR A CLEAN ENVIRONMENT #26303

FILMSTRIPS

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SUPPLEMENT #35

Student Worksheet - Political

Directions: Use the bibliography (political), the phone book, and any other available references in answering the questions given.

1. Find out who is on the local and state water pollution control board (that is, who sets water quality standards and who enforces the water quality laws).

2. Find out about the "1899 Refuse Act". It's written up in Our Troubled Waters: The Fight Against Water Pollution by Gladwin Hill. Respond to the fact that "some places" are discharging directly into our rivers!

3. Arrange to have someone from the Army Corps of Engineers talk to the class about their function in maintaining water quality, or research and report to the class your own findings.

4. List all the local, state, and federal agencies involved in water pollution control.

5. Who is the Mayor of our city? Does the Mayor have a responsibility concerning the quality of our city's drinking water? (You might wish to have an individual or group interview with the Mayor.)

6. Who are the local politicians in our city? (county commissioner, State representative, congressman, etc.). Give the responsibility of these local politicians and the role they play concerning local water quality.

7. List names and addresses of our district state representatives. Write each a letter asking for his stand on maintaining environmental quality. Ask also for his voting record on environmental bills.

8. Find out when the city council meets and who the members are. Can we go?

9. Find out when the county commissioners meet. Who are the county commissioners? Can we go to a meeting?

SUPPLEMENT #36

The Power Structure

To The Teacher

Each group of students make a chart like the one given below. Each group brainstorms to make a list of environmental agencies. Each group should write on the chart those agencies named. After several minutes all groups should share their results and then repeat the process for the governmental agencies (local, state, federal) they should be aware of as environmental activists. Again share the results. Do this one more time, requesting each group to list all interest groups and clubs they should be aware of in terms of their own class project. Now request the groups to write and draw arrows to groups indicating the steps they would take to solve their class project utilizing all available legal channels as well as unofficial influences.

CHART

The Power Structure

Environmental Agencies

Governmental Agencies

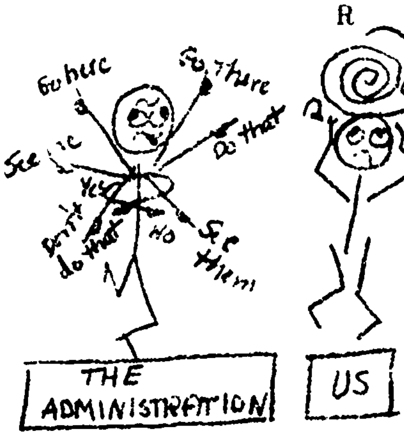
Unofficial Influences (clubs and their interest groups)

STENCIL

SUPPLEMENT #37

The POLITICS of Environmental Quality Control

O
R



"WHO DID YOU SAY I SHOULD CONTACT??"

LET'S FACE IT - BEING AN ENVIRONMENTAL ACTIVIST means never having to say you're BORED!
("know what I mean?")
No, you don't . . . UNLESS you've become an environmental activist (that's someone who doesn't sit around and wring his hands, crying "doom and gloom, we're all dying cough, cough" you know the type---)

This school course is almost over and ⟶ from now on you're on your own.

So what are YOU going to do?!

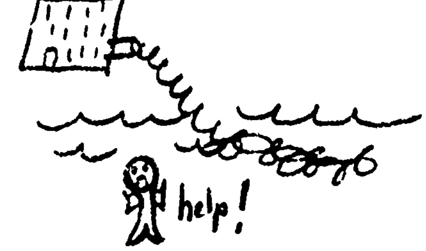
Please don't let us down. Keep on moving those mountains. Yell loudest. Push hardest. It's a battle: you against "them" (and you know who "them" are: those who don't care; or won't care; or who care, but won't DO).

Here are some final suggestions for those of you who have the courage and conviction to do what needs to be done: protect and preserve our fragile natural environment.

HEED THIS: You're going to have to work with the system, if you want to be heard. That is, follow the right legal channels that we now have for solving our environmental problems. To help you understand what I mean, let's take an environmental problem as an example and follow the proper steps in solving it:

PROBLEM

Someone is dumping a strange, colored waste into a drainage ditch and you are observant enough to notice it.



Supplement #37 (Cont.)

SOLUTION

Which of the following would you do?________________

a. call the County Health Department
b. call the mayor
c. call the State Department of Natural and Economic Resources "help line" 120-800-622-7308
d. call the City Director of Public Works
e. call the Chamber of Commerce to find out the names of local environmental groups and then contact them for help
f. collect a sample of the waste and take it to the Health Department and to the Board of Water and Air Resources (state government agency)
g. call or write the State office (in Raleigh) and the Federal office (in Washington, D.C.) or the Environmental Protection Agency (EPA)
h. call or write the Department of the Interior, Bureau of Sport Fisheries and Wildlife (there is usually a district office near you; ask the operator)
i. call or write the Environmental Protection Agency or the Department of Natural and Economic Resources and ask them the names of Environmental Action groups in your area you can contact for help

Which did you select: a? d? f? g? Or couldn't you decide?

Know what I would do? I'd call all NINE ! Why? BECAUSE

FIRST - I don't trust people to get things done and the more people I contact, the greater the chance of someone solving the problem.

SECOND - Few of those people you call will take the responsibility for solving the problem.

Please list here all the professionals (tell what office they hold) we used in class for our project. Circle those you learned the most from:

Supplement #37 (Cont.)

Now that you've got the professionals supposedly working on the problem, do you relax?

NO

Keep calling them to find out what they are doing!

Write letters to the local newspaper explaining what you saw and what is wrong with it.

ONE MORE THING ---

NEVER, NEVER believe anything <u>anyone</u> tells you. <u>Always</u> talk to as many people as you can, read as much as you can (in newspapers, magazines, the library) and then decide for YOURSELF what is true.

AND IF NO one will help you, do this:

1. Form a committee of people who feel the same way you do - often these will be people who are hurt in some way by the problem (like if it is a polluted stream, fishermen will be on your side).

2. Write news articles and talk door-to-door to convince people of what you want.

3. Try to get as many influential people on your side as you can.

4. Often, you can persuade the officials to see your side if you can give them a petition with as many signatures as you can get.

5. Prepare a questionnaire to find out what the citizens in town want and how much they know. This way you will know the kind of people you are dealing with.

Look the above 5 steps over and circle the ones we used in class on our project.

Supplement #37 (Cont.)

<u>AND</u> <u>ALWAYS</u>:

1. Write your congressmen and let them know what is important to YOU: clean water, clean air, trees, wildlife, etc. Suggest laws you think should be passed.

2. Get involved in your local government.

RUN FOR OFFICE	GO TO CITY COUNCIL MEETINGS WHEN YOU HAVE SUGGESTIONS OR NEED HELP IN STOPPING A POLLUTER	READ THE PAPER SO YOU WILL KNOW WHAT IS GOING ON AND GO TO PUBLIC HEARINGS TO MAKE <u>YOUR</u> OPINION KNOWN

AND IF YOU CAN'T GET ANYONE TO HELP YOU - DO IT YOURSELF IF YOU CAN - THEN LET PEOPLE <u>KNOW</u> YOU DID IT (write letters to the editor)

CLEAN UP AN ILLEGAL DUMP   PICK UP LITTER   PLANT GRASS TO HALT EROSION   DO ANYTHING, my friend BUT

DON'T

EVER

GIVE

UP

!!!

It can be a happy, beautiful world IF only . . . .

STENCIL

Pre-Post Test

HOW MUCH DO YOU KNOW ABOUT WATER QUALITY CONTROL?

ANSWER EITHER 1 or 2:

1. Pollution! It has been a hot rainy August. There is a thick green scum covering the surface of the __________ River. Fish are beginning to die.

   a. What is the scum?
   b. What caused the "scum" to appear?
   c. What part does the rain play in causing the pollution?
   d. What is causing the fish to die?
   e. What part does the heat play in causing the problem?

2. An elderly man describes his boyhood experiences swimming in the river near downtown ______. He describes the river bottom as sandy and filled with oysters and delicious clams.

   BUT:

   A geology professor went skindiving off river bank this past summer and describes the river very differently! He says the river bottom is black and oozy. That it is so cloudy near the bottom you cannot see your hand in front of your face. He also says there are no oysters and the one type of clam that does live down there cannot be eaten. There are only that one type of clam and worms living in the ooze.

   a. Is there a pollution problem? If you think so, name the pollutant (s) in the river.

   b. Why can't the clams be eaten?

ANSWER c and d only if you answered "YES" to "a" above:

   c. Think back to what the elderly man said, then to what the geologist said. What is so different now than a generation ago that caused this pollution to change the river so much in a generation's time?

   d. Where did the pollutants you named in a and b above come from?

POLLUTANT SOURCE

3. Everyone must answer no. 3: Solving the Pollution Problem.

For the questions you answered (either #1 or #2) also answer the following questions by filling in the chart with the information asked for.

SOLVING THE POLLUTION PROBLEM

Here is an explanation of the chart you fill in for question no. 3.

COLUMN 1:

POSSIBLE SOLUTIONS - List as many different ways as you can think of to solve the pollution problem in question #1 or #2 depending on which you answered. Explain specifically how to go about carrying out the solution. In other words, write a plan for solving the pollution problem.

COLUMN 2:

PROBLEMS YOU WILL ENCOUNTER - For each plan tell what the hangups or obstacles might be that may stop you or make your plan hard to carry out.

COLUMN 3:

HELP! - Name the people or groups that you could count on for support or assistance and explain how each would help.

COLUMN 4:

THE ENEMY - Name the people or groups that would be against you and explain why they would want to stop you.

ANSWER EITHER 4 or 5:

4. Fish kill! It has been a pleasantly cool week and yet fish are seen floating on the surface of the river. The officials have examined every possible polluter in and near ___________ that may be dumping pollutants into the river. No source has been uncovered. What do you think is causing the fish to die? Explain your reasoning.

5. Park rangers are concerned because the wildfowl that nest in the marshland along the National Seashore are not reproducing. An examination of their nests show many crushed eggs as well as tiny dead ducklings. Studies performed on the fowl show quantities of DDT in their bodies. But no DDT is used along the National Seashore. Explain completely how the DDT got into the wildfowl.

ANSWER SHEET FOR PRE-POST TEST

NAME: ______________________ DATE: ______________

Answer sheet: HOW MUCH DO YOU KNOW ABOUT WATER QUALITY CONTROL?

Write your answer for either 1 or 2. Be sure you number it correctly (#1 or #2)

No. ___ a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

2D

POLLUTANT (name above)	SOURCE OF POLLUTANT
1.	
2.	
3.	

No. 3 See next page

Write your answer to #4 or #5. Be sure you write in the correct number. (#4 or #5)

No. ___ ______________________________

CHART FOR ANSWERING NO. 3: SOLVING THE POLLUTION PROBLEM YOU ANSWERED IN EITHER #1 OR #2

NOTE: WHEN YOU FINISH THE CHART, CIRCLE THE SOLUTION YOU THINK WOULD HAVE THE BEST CHANCE OF WORKING

1. POSSIBLE SOLUTIONS	2. PROBLEMS YOU'LL ENCOUNTER	3. HELP HOW THEY'LL HELP	4. THE ENEMY NAME WHY THEY'LL DISAGREE
Solution No. 1	1. ______	1. ______	1. ______
	2. ______	2. ______	2. ______
	3. ______	3. ______	3. ______
	4. ______	4. ______	4. ______
Solution No. 2	1. ______	1. ______	1. ______
	2. ______	2. ______	2. ______
	3. ______	3. ______	3. ______
	4. ______	4. ______	4. ______
Solution No. 3	1. ______	1. ______	1. ______

KEY FOR PRE-POST TEST

No. 1.

a. algae or algal bloom

b. too many substances - fertilizers, sewage, detergents - with nutrients like phosphates and nitrates entering the water

c. the rain will wash these nutrients into the waterway; as a result of the rain, air pollutants will also enter the waterways; treated sewage is piped into the river

d. the algae are overpopulating because of the abundance of food; some of the algae will die and aerobic bacteria will begin to feed on the algae, this process is speeded up significantly so that eventually the available oxygen is used up and the fish die

e. naturally the algae will grow better under warm conditions and also this will cause a reduction in the amount of available oxygen

No. 2.

a. yes, such things as silt, raw sewage, bacteria, fertilizers and industrial wastes are probably present in the water

b. the water probably contains such pollutants as industrial wastes, fertilizers, raw sewage, silt, heavy metals, pathogenic bacteria, DDT, pesticides and consequently so do the clams

c. the changes in the river may have happened because (1) there are many more factories in operation; (2) there are more people and as a result more pollutants; (3) people's attitudes toward their environment is one of apathy; (4) different customs and lifestyles exist today that have created complex problems

d.

POLLUTANT	SOURCE OF POLLUTANT
1. industrial wastes	industries dumping untreated waste water containing chemicals into the water
2. fertilizers	aerial spraying, farm run-off or soil erosion
3. raw sewage	inefficient sewage treatment plants; water front homes which do not have septic tanks; farm animals
4. silt	farm run-off; soil erosion

POLLUTANTS	SOURCE OF POLLUTANT
5. heavy metals	industries releasing their products directly into the water
6. pathogenic bacteria	untreated human sewage entering the water
7. DDT	insecticides being sprayed near waterways and soil erosion
8. other pesticides	farm run-off and soil erosion

No. 3 The following answers are for question number 1.

Possible Solutions

1. water treatment for stormsewer water and settling basins
2. eliminate the sources of pollutants which are causing the algae bloom
3. have pesticides (those that create problems) banned
4. build better sewage treatment plants as present effluent might be providing nutrients for algae growth
5. require all residents on waterfront to have septic tanks, and enforce this requirement
6. limit the use of nitrate and phosphate fertilizers

Problems you'll Encounter for each solution

1. would cost too much money to build a new plant and settling basins; taxes would have to be increased to get the revenue; special persons would have to be trained to operate the plant
2. finding out just which industry is actually adding the pollutants; getting the support of the genoral public; getting the general public to become active about the problem
3. finding other ways or methods of eliminating pests; getting people to use natural controls; getting industries to do more research on effects of certain chemicals in the environment
4. getting the support of the people; raising the money necessary for another plant; making the public aware of future problems which could arise
5. making people aware and knowledgeable of effects of dumping raw sewage into waterways; getting people to abide by the laws; seeing that local health officials enforce the law
6. getting the support of farmers and industries that make such fertilizers; getting the public's support for such a law

HELP

1. the news media (newspaper, TV, radio) by bringing both sides of the issue to the public; public meetings could be held at which citizens could listen to experts discuss the issue; educate the public; involve politicians in getting a bond passed to provide the necessary funds
2. involve conservation groups, concerned citizens, students in trying to locate source of pollutants; the news media (newspaper, TV, radio) could present the problem to the public; local and state air and water resources persons
3. involve conservation groups; educate citizens about effects of substances and alternatives; gain support of the farmers; the news media (radio, TV, newspaper) could present specials about the problem
4. involve local organization such as the Jaycees to get public attention; utilize the news media; involve conservation groups; educate the public about the needs
5. health officials by showing and educating people about the effects of the pollutants; Department of Air and Water Resources could give detailed information; local conservation groups could gain public attention; news media could present differing viewpoints
6. Department of Air and Water Resources could give data relating to effects of fertilizers; local conservation groups could give public attention; news media could present the differing viewpoints to the public

THE ENEMY

1. city council - cost too much; local taxpayers - cost too much; downtown businesses - burden of expense would be upon them, same local town residents
2. industries - to install adequate filtering and treatment facilities would be expensive; unconcerned citizens - just not interested; local officials - too difficult to enforce
3. farmers - they need these substances in order to produce crops; fertilizers and pesticide industries - their business will be threatened
4. local officials - too expensive; taxpayers - they'll assume much of the cost
5. water front residents - too expensive; local officials - too difficult to enforce
6. farmers - they need these to produce crops; fertilizer industries - would effect their business

No. 3: The answers for question number 2 do not vary that much from #1, thus refer to the previous (#1) answers.

No. 4. The following are sample answers:
"The DDT from farm run-off may be carried to the marshland by the river since it is not biodegradable. Also migratory birds that return to the marsh in the spring to nest may have picked it up somewhere else or have eaten fish from that area."

"The pollution level has been building up over the years. The fish have taken all the pollutants into their bodies that they can take. So they die. Farm run-off can also be one of the pollutants. Pesticides and other chemicals as well as silt have been washed into the river. People used poor conservation practices."

No. 5. The following are sample answers:
"farmers sprayed crops with DDT; it rains; rain washed DDT into water; water reaches seashore; birds and wildlife drink water and eat sea life; DDT is now in their bodies----or sprayed insects build up resistance and wildlife eats the insects; the whole process is indirect"

"The DDT is used in the field and is transferred to the air and then to the ditches by rain. The ditches carry the DDT to the rivers and these rivers empty into the marshlands and the ocean. The DDT concentrates into smaller fish and then to larger fish. The wildfowl eat the fish and the DDT concentrates much more in them causing the egg shells to be fragile and to easily break, causing the ducklings to die. Only a few survive."

APPENDIXES

APPENDIX I

Suggested Student Projects

PROBLEM	PROJECT	PLANS FOR SOLVING	REASONS
1. lack of treatment for storm water	to send storm water to city treatment plant to remove pollutants	a) enlarge the existing plant, build large holding ponds to collect the water and hold it while large particles settle and oils are skimmed or absorbed off the top b) build another plant just to treat storm water (primary, secondary, tertiary treatment) c) build large septic tanks to remove the pollutants - only problem, these would have to be so huge	a) we want pure quality wate in all our waterways b) storm water contains germ and is a health hazard c) waterfront property value will increase d) storm water contains many pollutants: paint, grease, oil, germs, silt, dirt, garbage, pesticides, detergents, fertilizers, animal wastes, litter; these pollutants are either poisons or biodegradable or just plain unsightly; the biodegradable pollutants are eaten by bacteria which in turn use u all the oxygen in the river; the fertilizers causes algal blooms (eutrophication) e) so the water will be more usable for swimming, fishing boating, possibly drinking f) eliminate odors g) make your city more appealing to non-polluting industries and for tourists who will bring <u>money</u> to our city

Appendix I (Cont.)

PROBLEM	PROJECT	PLANS FOR SOLVING	REASONS
2 certain streams, creeks, and rivers are classified incorrectly	to reclassify a creek, stream, or river	a) find the sources of pollution and eliminate these sources; write a letter to the Department of Natural and Economic Resources, Board of Water and Air Resources requesting a hearing for reclassifying the body of water	a) we don't feel any body of water should be polluted b) other people may follow our lead, this would result in the upgrading and purification of all water c) this body of water (if of better quality) could be use for swimming, fishing, (and even as a source of drinking water) d) a park could be built along the banks of the body of water e) esthetic value (it would look better) f) as it is now this body of water pollutes other major waterways
3. areas of the city have septic tanks and many surrounding subdivisons have septic tanks	elimination of septic tanks from all subdivisions and connection of all subdivisions to city sewage treatment plant	decide on subdivisions to be included; publicize the project to gain support; obtain factual data to support plan (such as petition (51%) number of residents in each subdivision, closeness of each dwelling, how many septic tanks have been inspected and meet the standards	a) septic tanks don't drain well in clay soil; most subdivisions around here are bui on clay soil b) many of the subdivisions are built in low areas (fill in swamps) consequently drai age is poor and there can be a back-up of sewage and improper functioning of tanks c) septic tanks must be cleaned out and there is no place to dump the waste; many people dump the solids into a river or creek

Appendix I (Cont.)

PROBLEM	PROJECT	PLANS FOR SOLVING	REASONS
			d) in crowded areas, septic tanks are a health hazard because the effluent can seep into the ground e) most people don't even know how to properly care for a septic tank so it will even work right f) the effluent from septic tanks can pollute not only ground water, but surface waters also (rivers, lakes), especially if the ground is low as it is in certain area and floods frequently
4. Many streams are scheduled to be channelized without sufficient knowledge of the effects of channelization on the streams' environment	to study the effects of stream channelization and prepare an environmental impact statement for a stream scheduled to be channelized	study the environment of a channelized stream versus one that has not been; obtain factual data to support the plan by interviewing private citizens, conservationist, ecologist, lawyers, etc.; obtain information from the Department of Natural and Economic Resources and SCS (Soil Conservation Service) on the effects of channelization to a stream environment	a) channelization increases the flow of water and therefore increases the amount of silt deposited b) causes destruction of breeding areas for many species of fish c) many citizens do not realize that they (and not just those few who will benefit by land drainage) share the burden of the expense of the project d) almost every major creek in North Carolina is scheduled for channelization even though a detailed study of the effects of channelization on the total stream environment has not been on

Appendix 1 (Cont.)

PROBLEM	PROJECT	PLANS FOR SOLVING	REASONS
			e) channelization results in the loss of valuable wet lan (and we do <u>not</u> know what effects this will have on th <u>total</u> environment f) results in increased amounts of pollutants entering major water sources leading to destruction eventuall of salt marshes g) economically more suffer because of eventual increase pollution (and siltation of waterways) and loss of salt water marshes
5. many municipalities do not adequately treat waste water; such pollutants as heavy metals, phosphates, nitrates, persistent pesticides, and many types of bacteria remain in the "treated" water	to send waste water through primary, secondary, and tertiary treatment (to add chlorination of waste water to secondary process)	a) to enlarge the existing sewage treatment plant so that tertiary treatment is done that is necessary to remove such pollutants as heavy metals, etc. . . . . . b) to construct a chlorinator - so that chlorine gas is pumped through the waste water to kill disease-causing germs	a) disease-causing germs are entering the waterway b) many pollutants hazardous to our health and to the environment are being releas into the waterways and consequently, continuously recycling, continuously inflicting damage to the environment c) with the population increase there is an ever increasing demand for all waterways to be of highest quality d) many of the pollutants going through the treatment system and into the waterway may act as nutrients causing algal blooms leading to eutrophication

APPENDIX II

Publisher's Addresses

American Education Publication
Xerox Education Division
55 High Street
Middletown, Connecticut 06457

Ballantine Books, Inc.
101 Fifth Avenue
New York, N. Y. 10003

The Center for Cassette Studies, Inc.
8110 Webb Avenue
North Hollywood, California 91605

Coward-McCann, Inc.
200 Madison Avenue
New York, N. Y. 10016

David McKay Co., Inc
750 Third Avenue
New York, N. Y. 10017

Ginn and Company
Boston, Massachusetts 02117

Izaak Walton League of America
Glenview, Illinois 60025

John Hopkins Press
Baltimore, Maryland 21218

The MacMillan Co.
866 Third Avenue
New York, N. Y. 10022

Manufacturing Chemists Associations
1825 Connecticut Avenue, N.W.
Washington, D. C. 20009

The Michie Company
Charlottsville, Virginia 22902

National Education Association of the U. S.
1201 16th Street, N.W.
Washington, D. C. 20036

National Wildlife Federation
1412 16th Street, N.W.
Washington, D. C. 20036

Natural History Press
Doubleday & Co.
501 Franklin Avenue
Garden City, N. Y. 11530

Pendulum Press, Inc.
West Haven, California 95530

Prentice-Hall, Inc.
Englewood Cliffs
New Jersey 07632

Public Affairs Committee, Inc.
381 Park Avenue South
New York, N. Y. 10016

Row, Peterson and Co.
Evanston, Illinois 60204

Scientist's Institute for Public Information
30 East 68th Street
New York, N. Y. 10021

Scope
Room 702
911 Walnut
Kansas City, Missouri 64106

Superintendent of Documents
U. S. Government Printing Office
Washington, D. C. 20402

University of Wisconsin Press
Box 1379
Madison, Wisconsin 53701

Viking Press, Inc.
625 Madison Avenue
New York, N. Y. 10022

Ward's Natural Science Establishment, Inc.
P. O. Box 1712
Rochester, N. Y. 14603

Washington Square Press
630 5th Avenue
New York, N. Y. 10020

Yale University Press
New Haven, Connecticut 06510

Note: this is a partial list of publishers. If you find that a needed address is missing, call your public library.